भारतीय मानक
Indian Standard

IS 17004 : 2018

संसाधित कांच के लिए परीक्षण विधियाँ

Testing Methods for Processed Glass

ICS 81.040.20

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September 2018 **Price Group 13**

Glass, Glassware and Laboratoryware Sectional Committee, CHD 10

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Glass, Glassware and Laboratoryware Sectional Committee had been approved by the Chemical Division Council.

Processed glasses are glass products that have been subjected to controlled thermal or chemical treatments to increase its strength compared to normal glass. Toughened safety glass, laminated safety glass and heat strengthened glass are a few examples of processed glass.

This Indian Standard prescribes the recommended testing methodology and equipment description for testing the requirements of different types of processed glass. The Committee responsible for formulating this standard felt that a standard which compiles different test methods available for types of processed glass would help raise the level of architectural glass testing in India to be at par with international level. For the development of this standard, significant contributions have been made by Glazing Society of India and IIT Madras.

In the formulation of this standard, considerable assistance has been derived from the following publications:

ASTM C 1048	Standard specification for heat-strengthened and fully tempered flat glass
ASTM C 1172	Standard specification for laminated architectural flat glass
ASTM C 1279	Standard test method for non-destructive photo elastic measurement of edge and surface stresses in annealed, heat-strengthened, and fully tempered flat glass
ASTM E 2649	Standard test method for determining argon concentration in sealed insulating glass units using spark emission spectroscopy
EN 1279-Part 1, Part 2, Part 3 and Part 6	Glass in building — Insulating glass units
	Part 1: Generalities, dimensional tolerances and rules for the system description
	Part 2: Long term test method and requirements for moisture penetration
	Part 3: Long term test method and requirements for gas leakage rate and for gas concentration tolerances
	Part 6: Factory production control and periodic tests
EN 1863-Part 1 and part 2	Glass in building — Heat strengthened soda lime silicate glass
	Part 1: Definition and description
	Part 2: Evaluation of conformity/product
EN 1215-Part 1 and Part 2	Glass in building — Thermally toughened soda lime silicate safety glass
	Part 1: Definition and description
	Part 2: Evaluation of conformity/product standard
EN 14449	Glass in building — Laminated glass and laminated safety glass — Evaluation of conformity/product standard
ISO 1288-3	Glass in building — Determination of the bending strength of glass — Part 3: Test with specimen supported at two points (four point bending)
ISO 12540	Glass in building — Tempered soda lime silicate safety glass
ISO 12543-Part 1 to Part 6	Glass in building — Laminated glass and laminated safety glass
	Part 1: Definitions and description of component parts
	Part 2: Laminated safety glass
	Part 3: Laminated glass
	Part 4: Test methods for durability
	Part 5: Dimensions and edge finishing
	Part 6: Appearance
ISO 29584	Glass in building — Pendulum impact testing and classification of safety glass

(Continued on third cover)

Indian Standard

TESTING METHODS FOR PROCESSED GLASS

1 SCOPE

This standard prescribes the testing methodology and equipment description for testing the requirements prescribed or otherwise for different types of processed glass like toughened safety glass, laminated safety glass, heat strengthened glass and insulating glazing unit, meant for general purposes such as for use in glazing windows, facades, doors and other architectural purposes.

2 REFERENCES

The standards given below contain provisions which, through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

IS No.	*Title*
IS 1382 : 1981	Glossary of terms related to glass and glassware (*first revision*)
IS 2553 (Part 1) : 2018	Safety glass — Specification: Part 1 Architectural, building and general uses (*fourth revision*)
IS 2835 : 1987	Specification for flat transparent sheet glass (*third revision*)
IS 14900 : 2018	Transparent float glass — Specification (*first revision*)

3 TERMINOLOGY

For the purpose of this standard, the definitions given in IS 1382, IS 2553 (Part 1), IS 2835 and IS 14900, in addition to the following shall apply.

3.1 Bending Strength

Bending stress or effective bending stress which leads to breakage of the test specimen subjected to a bending force.

3.2 Equivalent Bending Strength

Apparent bending strength of patterned glass, for which the irregularities in the thickness do not allow precise calculation of the bending stress.

3.3 Heat Strengthened Glass

A single piece of glass within which a permanent surface compressive stress, additionally to the basic mechanical strength, has been induced by a controlled heating and cooling process in order to give it increased resistance to mechanical and thermal stress and prescribed fracture characteristics.

3.4 Insulating Glazing Unit

An assembly consisting of at least two panes of glass, separated by one or more spacers, hermetically sealed along the periphery, mechanically stable and durable.

3.5 Standard Laboratory Conditions

Ambient temperature of 27 ± 2°C and a relative humidity of 65 ± 5 percent.

4 RECOMMENDED TESTS FOR ARCHITECTURAL PROCESSED GLASS

The tests listed in col 1 of Table 1 are the tests recommended to be performed for the corresponding types of processed glass in col 2 to 5, as indicated by the 'Y' symbol. The number of samples required for each test may be determined as per this standard or the respective product standard.

5 TEST FOR PHYSICAL ATTRIBUTES

5.1 Thickness Measurement

The actual thickness shall be the average of four measurements, taken to the nearest 0.01 mm, each one taken at 25 mm away from the edge at the centre of each side as shown in Fig. 1.

Measurement shall be done by means of an instrument of the calliper/micrometre type, duly calibrated.

Additional measurements shall be taken at each corner in the case of insulating glazing units.

Table 1 Recommended Tests for Processed Glass

(*Clause* 4)

Testing Parameters (1)		**Toughened Safety Glass** (2)	**Laminated Safety Glass** (3)	**Heat Strengthened Glass** (4)	**Insulating Glazing Unit** (5)
Test for Physical Attributes					
Thickness and Dimension		Y	Y	Y	Y
Flatness	Overall bow	Y	Y	Y	
	Wave and Roller wave	Y		Y	
	Edge lift	Y		Y	
	Local Distortion	Y		Y	
Test for Mechanical Properties					
Fragmentation test		Y		Y	
Resistance to Shock test		Y			
Fracture and Adhesion test			Y		
Four point bending		Y		Y	
Resistance to human impact		Y	Y		
Surface Compression		Y		Y	
Test for Durability					
High Temperature test	Boil Test		Y		
	Bake Test		Y		
Humidity test	With condensation		Y		
	Without condensation		Y		
Radiation test			Y		
Climate test					Y
Argon Gas level test					Y
Light stability test			Y		

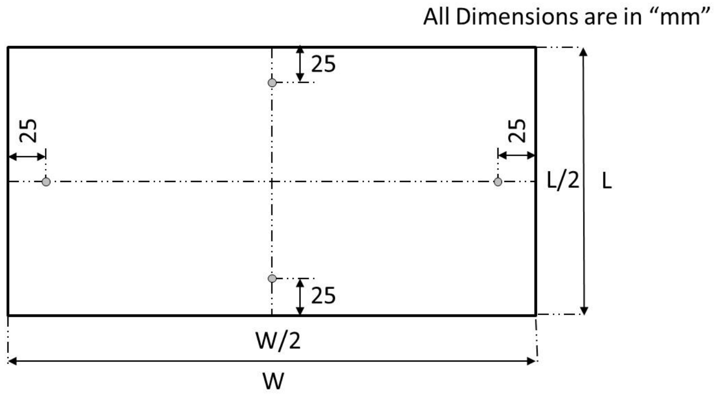


FIG. 1 POINTS FOR MEASUREMENT OF THICKNESS

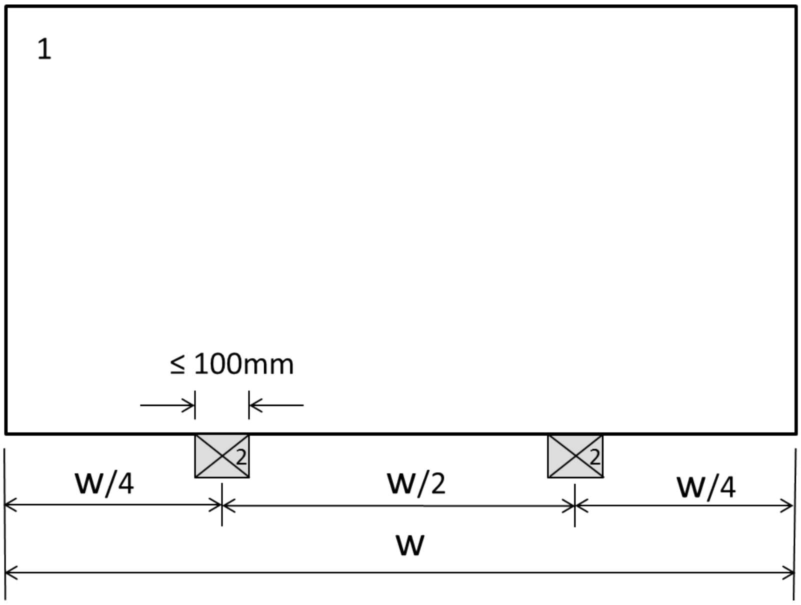
5.2 Measurement of Overall Bow

The pane of glass shall be placed in a vertical position and supported on its longer side by two load bearing blocks at the quarter points (*see* Fig. 2).

The deformation shall be the maximum distance between a straight metal ruler or a stretched wire joining the corners of the glass, and the concave surface of the glass. The deformation shall be measured along the edges of the glass and along the diagonals (*see* Fig. 3). The deformation shall be measured by means of a feeler gauge or a taper gauge, as applicable.

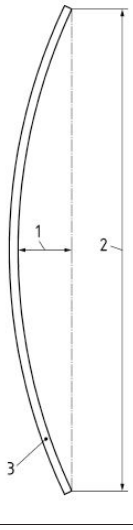
The measurement shall be carried out at room temperature.

NOTE — Results from this test method for glasses thinner than 4 mm may be inaccurate.



Key	
1	Glass
2	Support

FIG. 2 SUPPORT CONDITION FOR THE MEASUREMENT OF OVERALL BOW



Key	
1	deformation (overall bow)
2	W, or L, or diagonal length
3	Glass

FIG. 3 REPRESENTATION OF OVERALL BOW

5.3 Measurement of Wave and Roller Wave

5.3.1 *General*

The wave or roller wave is measured by means of a straight edge, or equivalent, being placed at right angles to the wave or roller wave direction and bridging from peak to peak of the waves (*see* Fig. 4).

NOTE — This section deals with measurement using a straight edge and feeler gauges. An alternative method with any other suitable equipment may also be used to measure the same.

5.3.2 *Limitations*

The following limitations apply:

a) The wave and roller wave can only be measured on panes with a dimension greater than 600 mm, measured at right angles to the direction of wave and roller waves.

b) The wave and roller wave cannot be measured in an exclusion area that is 150 mm from the edges of the pane as different types of deformation may be present in this area. The apparatus should not be used in this area.

c) Panes with an overall bow can be laid on a flat support. This will allow gravity to flatten out the overall bow and hence give a realistic result for the roller wave.

5.3.3 *Apparatus*

5.3.3.1 *A straight edge* — Length of between 300 mm and 400 mm.

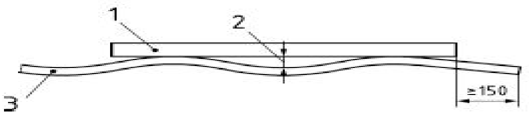
NOTE — The minimal length of the straight edge needs to bridge two peaks of the roller waves.

5.3.3.2 *Feeler gauges* — various thicknesses in units of 0.05 mm.

5.3.4 *Method*

Place the straight edge so that it bridges across adjacent peaks. Insert the feeler gauge between the glass surface and the straight edge. Increase the thickness of the feeler gauges until they just fill the gap between glass surface and the straight edge. Record the thickness of feeler gauge(s) to an accuracy of 0.05 mm.

Repeat the measurement at several places over the glass surface.



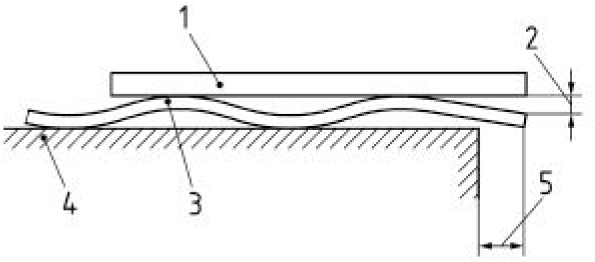
Key	
1	Straight edge
2	Wave or roller wave distortion
3	Glass

FIG. 4 MEASUREMENT OF WAVE OR ROLLER WAVE DISTORTION

5.4 Measurement of Edge Lift (For Horizontally Toughened Glass Only)

The glass shall be placed horizontally on a flat supporting surface which has dimensions equal to or greater than the dimensions of the glass to be tested. The table or surface should be free of debris and any other surface condition that may affect the measurement. To measure edge lift, one end of the glass should overhang the edge of the support by 50 mm to 100 mm. The straight edge is placed on the peaks of the roller waves and the gap between the straight edge and the glass is measured using a feeler gauge (*see* Fig. 5).

NOTE — The minimal length of the straight edge needs to bridge two peaks of the roller waves and the length of the edge lift.



Key	
1	Straight edge
2	Edge lift
3	Glass
4	Flat support
5	Overhang of 50mm to 100mm

FIG. 5 MEASUREMENT OF EDGE LIFT

5.5 Measurement of Local Distortion (For Vertically Toughened Glass Only)

5.5.1 Local distortion can occur over relatively short distances on the edge of the vertically toughened glass that contains the tong marks.

5.5.2 Local distortion shall be measured over a limited length of 300 mm. It shall be measured parallel to the edge at a distance of 25 mm from the edge of the glass, as the maximum distance between a straight metal ruler placed on the pane and local distortion (*see* Fig. 6). The deformation shall be measured by means of a feeler gauge or a taper gauge, as applicable.

5.5.3 Local distortion is expressed as millimetres/300 mm length.

6 TEST FOR MECHANICAL PROPERTIES

6.1 Fragmentation Test

6.1.1 *General*

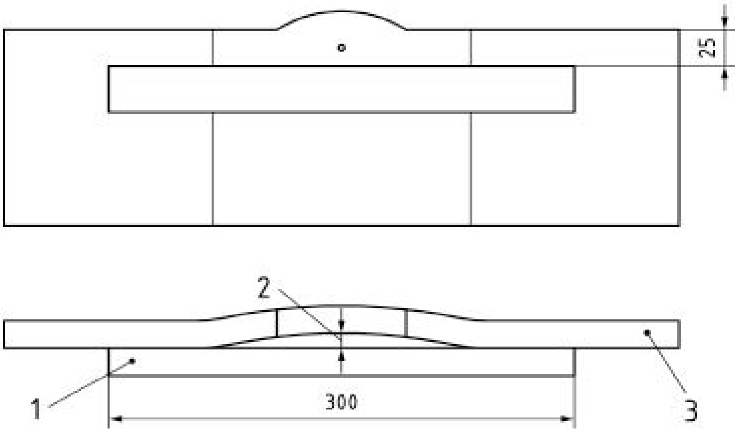
The fragmentation test determines whether the glass breaks in the manner prescribed for a thermally toughened safety glass/heat strengthened glass.

6.1.2 *Area and Number of Test Specimens*

The minimum area of the test specimen shall be 0.36 m^2 without any holes, notches or cut-outs. Five specimens shall be tested.

6.1.3 *Test Procedure*

Each test specimen shall be impacted, using a pointed steel tool, positioned at midpoint of the longest edge of the test specimen, distanced 13 mm in from the edge, until breakage occurs (*see* Fig. 7). Examples of steel tools used for testing are a hammer of about 75 g mass, a spring loaded centre punch, or other similar appliance with a hardened point. The radius of curvature of the impact point should be approximately 0.2 mm.



Key	
1	Straight edge
2	Local distortion
3	Glass

FIG. 6 MEASUREMENT OF LOCAL DISTORTION

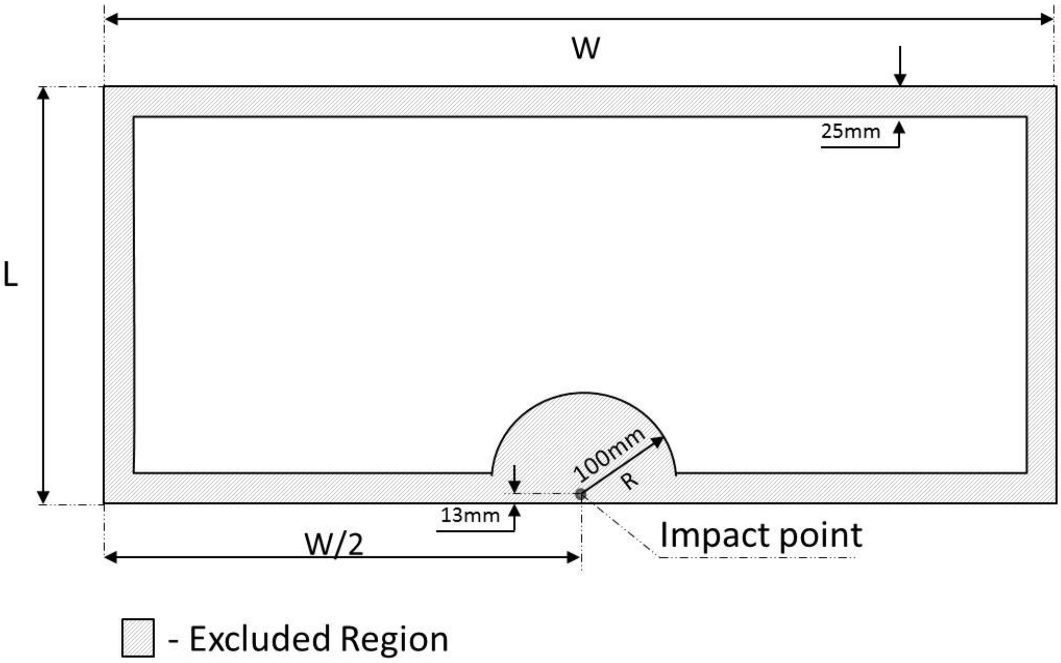


FIG. 7 FRAGMENTATION TEST

The test specimen shall be laid flat on a table without any mechanical constraint. In order to prevent scattering of the fragments, the specimen shall be simply held at the edges, for example, by a small frame, adhesive tape etc., so that the fragments remain interlocked after breakage yet extension of the specimen is not hindered.

For thermally toughened safety glass manufactured by vertical toughening, the impact point shall not be on the tong mark edge.

6.1.4 *Assessment of Fragmentation for Toughened Safety Glass*

The particle count and measuring of the dimensions of the largest particle shall be made between 3 min to 5 min after fracture. An area of radius 100 mm, centred on the impact point, and a border of 25 mm, around the edge of the test specimen (*see* Fig. 7), shall be excluded from the assessment.

The particle count shall be made in the region of coarsest fracture (the aim being to obtain the minimum value). The particle count shall be made inside a square frame of (50 ± 1) mm × (50 ± 1) mm on the test piece or by any other suitable means. The number of crack-free particles within the square shall be counted. A particle is 'crack-free' if it does not contain any cracks which run from one edge to another [*see* Fig. 8(a)].

The particle count determination of glass sheet shall be completed within 5 min of the fracture of that glass. No magnifying lens or other aid to vision (except spectacles if normally worn) shall be used when making the particle count as described below.

All particles wholly contained within the area of the square frame shall be counted as one particle each and all the particles which are partially within the square frame shall be counted as 1/2 particle each.

6.1.4.1 *Minimum values from the particle count*

In order to classify a glass as a thermally toughened safety glass, the particle count of each test specimen shall not be less than the values prescribed in Table 2.

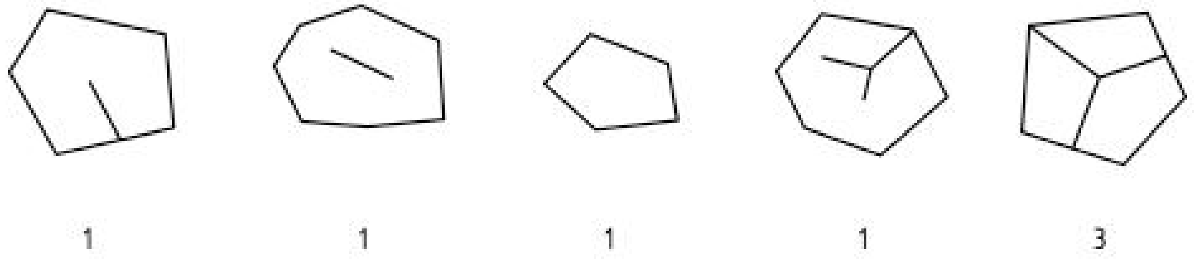
6.1.4.2 *Selection of the longest particle*

The longest particle shall be chosen from the body of the test specimen. It shall not be in the excluded area (*see* Fig. 7).

6.1.4.3 *Maximum length of longest particle*

In order to classify the glass as thermally toughened soda lime silicate safety glass, the length of the longest particle shall not exceed 100 mm.

6.1.5 *Assessment of Fragmentation for Heat Strengthened Glass*



Key	
–	Number of perimeter particles = Number of particles in the perimeter /2
•	Number of central particles
Total particle count = Number of perimeter particles + Number of central particles	

Fig. 8(A) Examples of Crack-Free Particles and The Assessment Regarding the Number G. Dew/Hall be Made Between 3

Table 2 Minimum Particle Count Values

Glass Type	Nominal Thickness (mm)	Minimum Particle Count (Number)
All glass types	4 to 12	40
	15 to 25	30

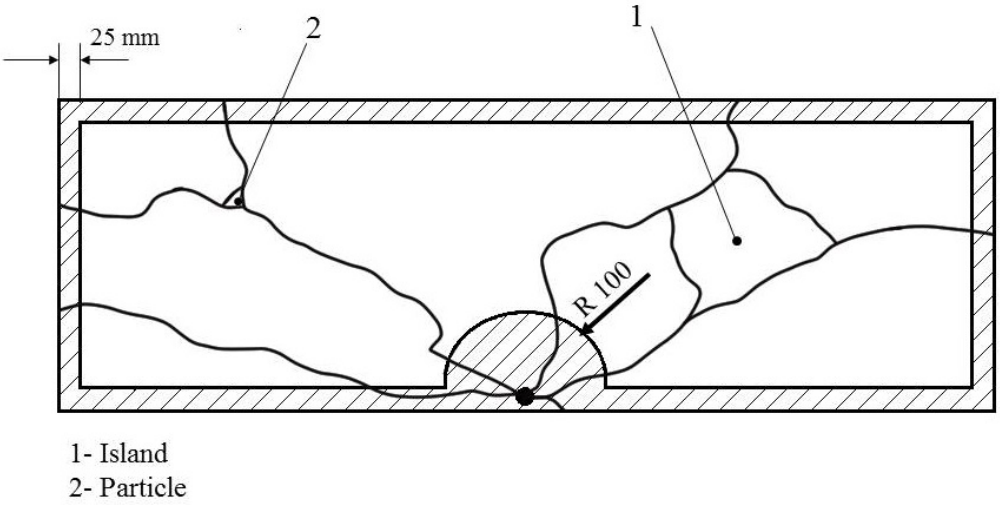


FIG. 9 HEAT STRENGTHENED GLASS AFTER FRAGMENTION TEST

Each test specimen shall be examined for its fragmentation pattern within 5 min of fracturing the glass. An area of radius 100 mm, centred on the impact point, and a border of 25 mm, around the edge of the test specimen (*see* Fig. 9), shall be excluded from the assessment.

Each fragment produced during the test shall be assessed as follows:

a) At least one edge of the fragment shall reach the excluded area (*see* Fig. 9). The particle count and measuring of the dimensions of the largest particle shall be made between 3 to 5 min after fracture.
b) Where no edge of the fragment reaches the excluded area (*see* Fig. 9), either an island or a particle is produced. Particles are fragments with area/mass equivalent less than 100 mm². Islands are fragments with area/mass equivalent greater than or equal to 100 mm².
c) The number of island fragments shall be counted and each island shall be weighed.
d) The particles shall be collected and weighed.

NOTE — Area = mass / (thickness × density), for example, a fragment of 6 mm thick glass of mass 1.5 g has an area/mass equivalent of 100 mm².

At least four out of five specimens shall meet the following requirements:

a) Each test specimen shall not have more than 2 island fragments;
b) Each test specimen shall not have any island fragments with area/mass equivalent exceeding 1 000 mm²; and
c) Each test specimen shall not have the area/mass equivalent of all particles exceeding 5 000 mm².

If one of the five specimens fails to meet those requirements, then it shall meet the following requirements:

a) Each specimen shall not have more than 3 island fragments; and
b) The area/mass equivalent of all islands and particles, shall not exceed 50 000 mm².

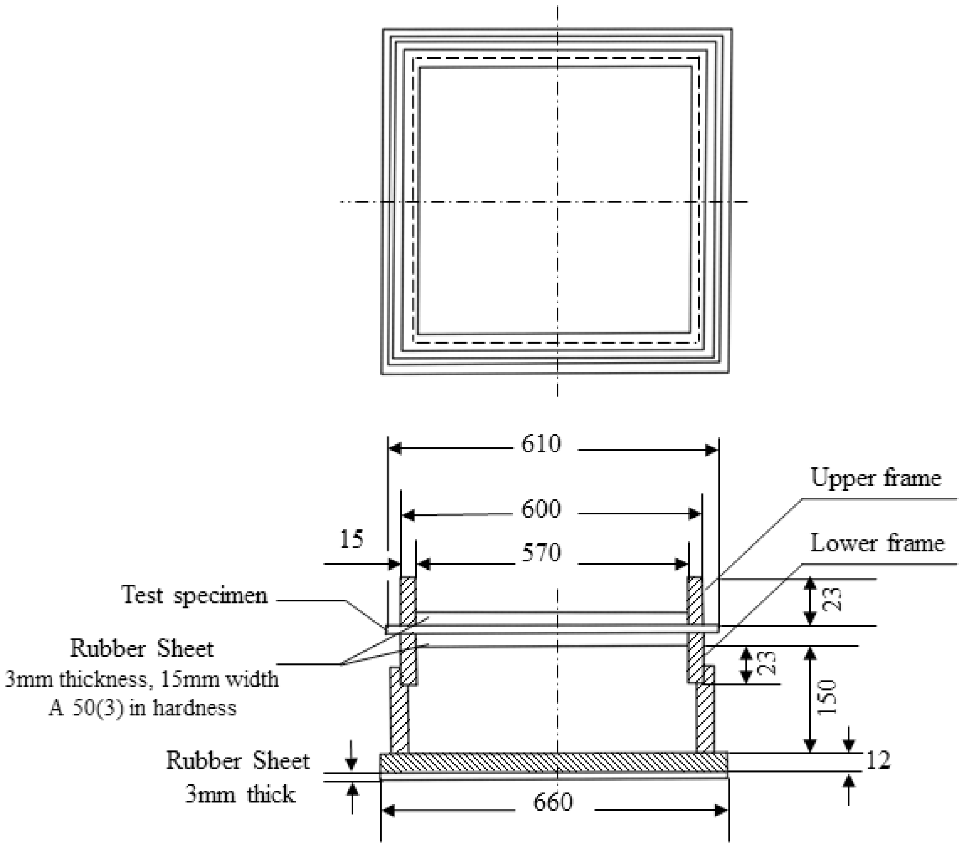
If the fragmentation of any glass proves to be unsatisfactory, three additional glasses shall be taken from the lot, and the test repeated. Reject the lot if any of the additional three samples fails to meet the requirements mentioned above.

6.2 Ball Drop Test

6.2.1 *Method for Toughened Safety Glass (Resistance to Shock)*

6.2.1.1 Five samples of toughened safety glass of dimensions 610 mm × 610 mm shall be used for the test. The test specimen shall be supported with an iron frame as shown in Fig. 10 so that it becomes horizontal. A steel ball of about 63.5 mm in diameter and weighing 1 040 ± 2 g with smooth surface shall be dropped freely from a height of 100 cm so as to strike the specimen within 25 mm from its centre. An electro-magnetic operated device may conveniently be used for this purpose.

The number of impact per test specimen shall be limited to one and the test shall be carried out at room temperature.



All dimensions are in "mm"

FIG. 10 BALLDROP TEST FOR TOUGHENED SAFETY GLASS

6.2.1.2 *Interpretation of results*

The product lot shall be accepted if not more than one sample is broken and shall be rejected if 3 or more of them are broken. When two samples are broken, another 5 samples shall be tested and the lot shall be accepted if all the five pass the test.

6.2.2 *Method for Laminated Safety Glass (Fracture and Adhesion)*

6.2.2.1 *Method 1*

Ten samples of laminated safety glass of dimensions 300 mm × 300 mm shall be used for the test. The test specimen shall be supported on a square hard wood frame having dimensions as shown in Fig. 11 so that the test specimen rests symmetrically. The frame shall be rigidly mounted on 12 mm steel plate, the screws or bolts used for attaching it to the steel plate shall not project below the under surface of the plate. The complete frame shall stand upon a substantial concrete bed. Prior to test, each specimen shall be weighed and conditioned at 27 ± 2°C for 4 h and immediately proceed for the test. A steel ball of about 38 mm in diameter and weighing 225 ± 2 g with smooth surface shall be dropped freely from a height of 4.88 m so as to strike the specimen within 25 mm from its centre. An electro-magnetic operated device may conveniently be used for this purpose.

The fragments from the under surface of each specimen shall be separately collected and weighed.

The lot shall be deemed to have passed the test, if

a) Out of the 10 specimen tested, the number of specimens shown to be pierced in the test does not exceed four of which not more than two are brittle (*see* Note below);

b) The total weight of the fragments from under side of the unpierced specimens does not exceed 0.5 percent of the total weight of those unpierced specimens; and,

c) No unpierced specimen yields any fragment which individually weighs more than 0.5 g.

NOTE — The specimen will be deemed to have been pierced if the split or tear exceeding 38 mm in length develops in the interlayer. A pierced specimen shall be deemed to be brittle if it breaks into two or more large pieces or if the fracture is sufficient to allow the ball to pass through.

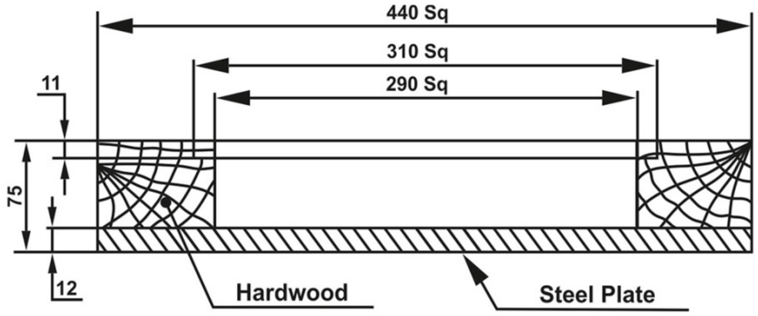
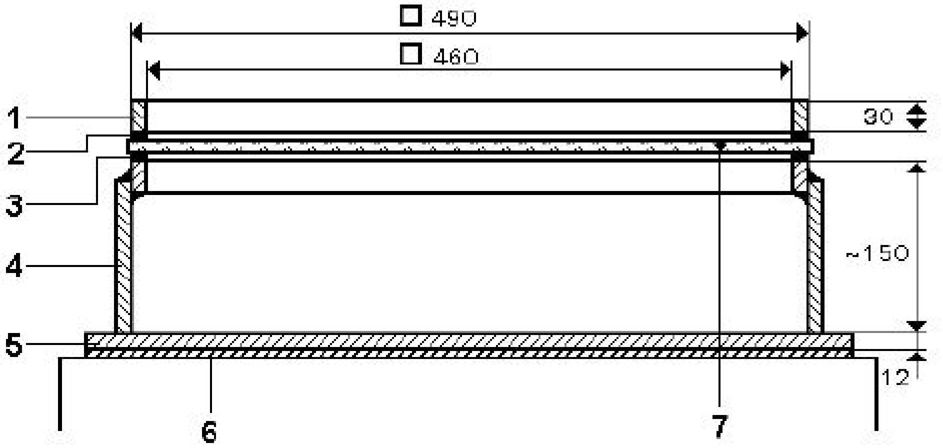


FIG. 11 BALLDROP TEST FOR LAMINATED SAFETY GLASS — METHOD 1

Dimensions in millimetres



Key	
1	Upper frame
2	Rubber
3	Rubber
4	Lower frame
5	Base plate
6	Rubber Interlayer
7	Test specimen

FIG. 12 POSITIONING OF TEST SAMPLE

6.2.2.2 *Method 2*

a) *Equipment* — A steel ball of 63.5 mm in diameter and weighing 1 040 ± 2 g with smooth surface shall be dropped freely from a height of 4 m so as to strike the specimen within 100 mm from its centre. An electro-magnetic operated device may conveniently be used for this purpose. The test specimen shall be positioned in accordance with Fig. 12. The positioning equipment shall consist of two steel frames. The edges of the frame should have a width of 15 mm, and should be covered with rubber strips, 15 mm wide and 3 mm thick, with a hardness of 40 ± 10 IRHD. The upper frame should have a mass of approximately 7 kg. The equipment shall be mounted on a 12 mm thick steel base plate. Between the base plate and the solid support, a 3 mm rubber mat, hardness 40 ± 10 IRHD should be used.

b) *Number of test specimen* — Ten test specimens of dimensions 500 ± 5 mm × 500 ± 5 mm shall be tested.

c) *Procedure* — The test specimen should be stored at least four hours at test temperature, preferably 27±2°C. After placing a test specimen in the supporting equipment, the ball shall be positioned at the required height and released.

d) *Interpretation of result* — The ball shall not penetrate the test specimen within 5 s after impact.

6.3 Mechanical Strength Test — Four Point Bending Test

6.3.1 *Equipment Description*

The equipment shall be capable of applying stress on the specimen from zero to a maximum value at the specified rate, in a uniform manner which minimizes shock. The testing machine shall incorporate a load measuring device with a limit error of ± 2 percent within the measuring range. The supporting rollers and the bending rollers shall have diameter of 50 mm and length not less than 365 mm. All the rollers shall be free to rotate.

6.3.2 *Dimension and Thickness Measurement*

The dimension and thickness shall be measured as per **5.1**. In case of specimens with one or two ornamental surfaces, both the plate thickness and core thickness shall be measured.

6.3.3 *Bending Test*

The specimen shall be mounted on a 3 mm thick strip of rubber of hardness 40 ± 10 IRHD. The rubber strip shall be placed between the specimen and the bending and the supporting rollers. The bending test shall be carried out at standard laboratory conditions. During the test, the temperature shall be maintained within ±1°C, in order to avoid the development of thermal stress. The specimen shall be bent with a bending stress uniformly increasing at a rate of 2 ± 0.4 N/mm^{2}s until failure occurs. The maximum load F_{max} shall be measured and the time taken to reach this load shall be recorded.

6.3.4 *Evaluation*

For evaluation purposes, only those specimens shall be considered in which the origin of fracture lies between the bending rollers. The bending strength shall be calculated in accordance with equation (1) as follows.

For a rectangular cross section (where $Z = Bh^2/6$) with the load applied as shown in Fig. 13, the bending strength, σ_{bB}, is shall be calculated in accordance with equation 1.

$$\sigma_{bB} = k\left[\sigma_{bG} + \frac{3F_{\max}(L_s - L_b)}{2Bh^2}\right] \quad \dots (1)$$

Note — *See* Annex A for list of symbols and notations.

The bending stress, σ_{bG}, imposed by the self-weight of the specimen shall be calculated in accordance with equation 2.

$$\sigma_{bG} = \frac{3\rho g L_s^2}{4h} \quad \dots(2)$$

For calculating the overall bending strength or equivalent bending strength of the surface area, including the edge beyond the bending rollers, the value k = 1 shall be used.

The factor k used in equation (1) depends on the deflection of the specimen at its centre. The central deflection, y can be determined by direct measurement or calculated with sufficient accuracy from equation (3).

$$\frac{y}{h} = \frac{3F_{\max}}{4EBh^4}\left[\frac{L_s^3}{3} + \frac{L_b^3}{6} - \frac{L_s L_b^2}{2}\right] \quad \dots(3)$$

The appropriate value of k for use in equation (1) shall be obtained from Fig. 14, which gives the value of k as a function of the value of y/h.

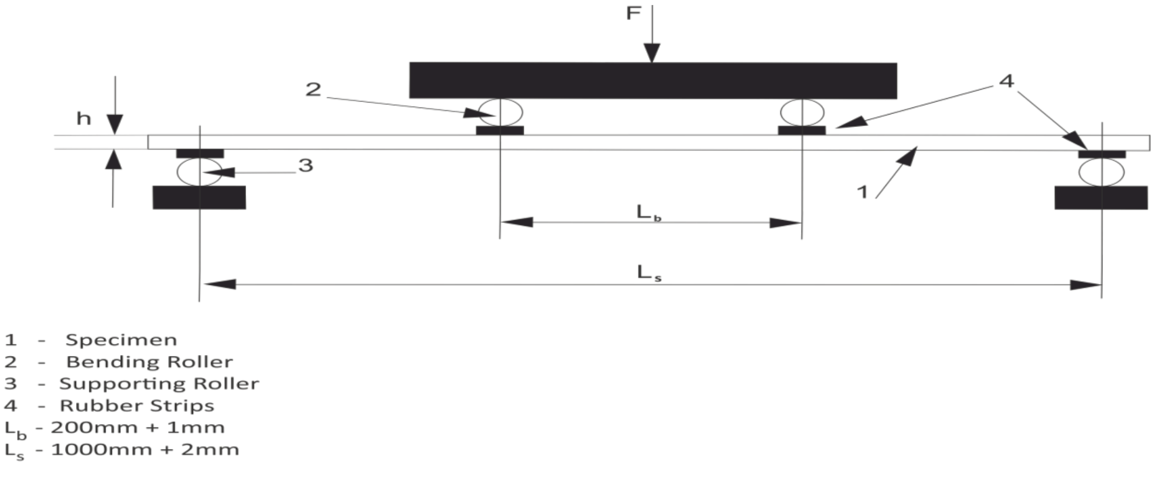


FIG.13 FOUR POINT BENDING TEST

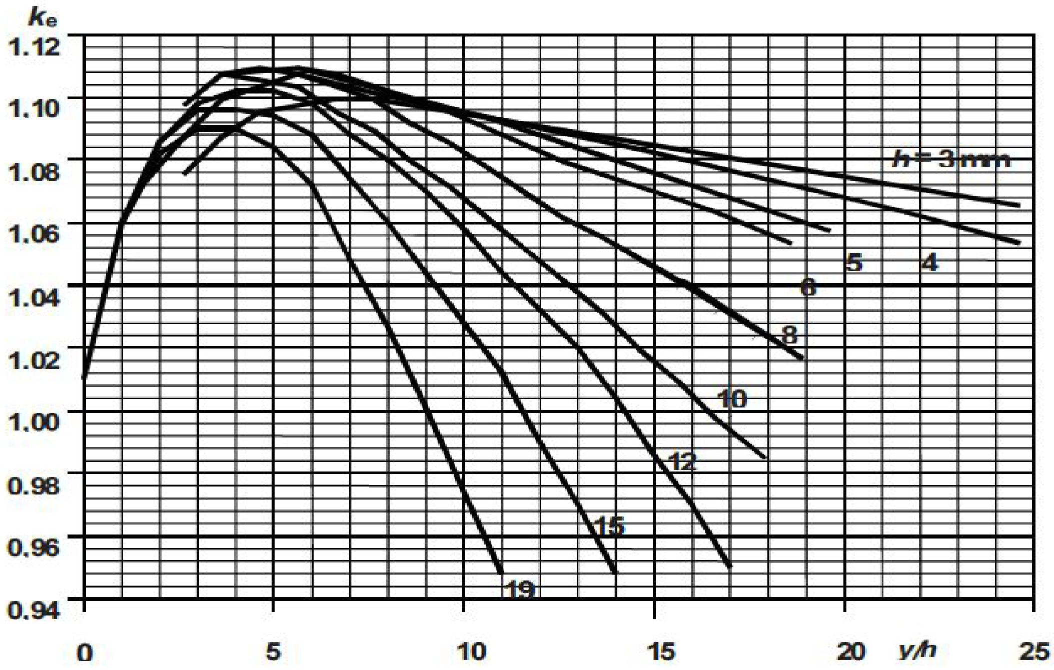


Fig. 14 Dimentionless Factor K as a Function of Y/H.

Note — For calculating the bending strength or equivalent bending strength of the free edges of the glass, only those specimens which fracture from the edge shall be taken into consideration.

When some of the specimens do not break from the edge, the set of edge strength results is not a true representation of the distribution of edge strength. The test specimens which does not break from the edge during the test tend to have higher edge strength compared to bending strength. There are however, statistical techniques which can take in to account the unmeasured edge strength of those specimens.

6.4 Resistance to Human Impact

6.4.1 *Test Requirements*

6.4.1.1 When tested by the method given in **6.4.4**, each test piece shall either not break or shall break as defined in one of **6.4.1.2** or **6.4.1.3**.

6.4.1.2 Numerous cracks may appear, but no shear or opening is allowed within the test specimen through which a 76 ± 1 mm diameter sphere can pass when a maximum force of 25 N is applied (in accordance with **6.4.7**). Additionally, if particles are detached from the test piece up to 3 min after impact, they shall, in total, weigh not more than the mass equivalent to 10 000 mm^2 of the original test piece. The largest single particle shall weigh not more than the mass equivalent of 4 400 mm^2 of the original test piece. If disintegration occurs, the 10 largest crack-free particles collected within 5 min of impact shall weigh not more than the mass equivalent to 6 500 mm^2 of the original test piece. The particles shall be selected only from the portion of the original test piece exposed in the test frame. Only the exposed area of any particle retained in the test frame shall be taken into account in determining the mass equivalent.

6.4.1.3 The 10 largest crack-free particles collected within 3 min after impact shall weigh not more than the mass equivalent of 6 500 mm^2 of the original test piece.

6.4.2 *Test Apparatus*

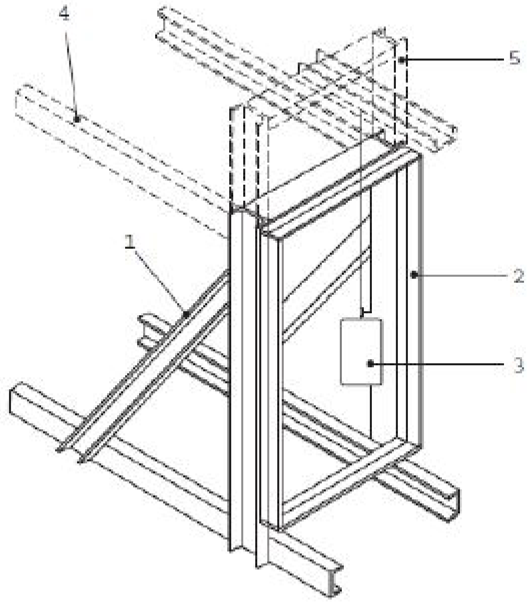
6.4.2.1 *Main frame*

Constructed from welded or bolted, hot-rolled steel channel sections with rounded edges, designed to present a rigid and flat surface to the sub-frame (*see* Fig. 15 and 16). The lower cross members shall be securely fixed to a concrete floor.

NOTE — Additional support to the frame can be provided, if required, by means of horizontal steel sections fixed to an adjacent rigid wall (*see* Fig. 15, key 4).

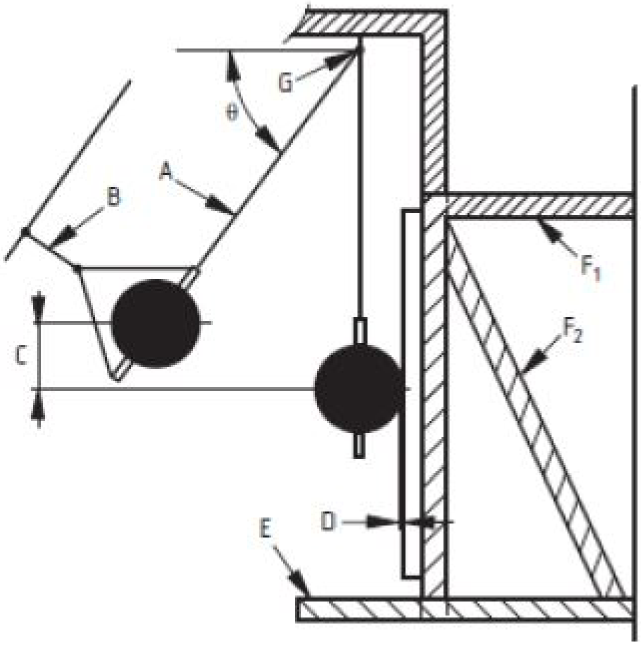
The dimensions of the main frame (*see* Fig. 17) shall be as follows:

a) internal width: (847 ± 5) mm; and
b) internal height: (1 910 ± 5) mm.



Key	
1	Main frame
2	Clamping frame
3	Impactor
4	Optional support member
5	Optional suspension device

FIG. 15 TEST FRAME



Key	
A	Suspension cable
B	Traction cable
C	Drop height

D	Impactor distance from Sample
E	Support member
F1	Optional support member
F2	Cross member
G	Bracket (5mm ≤ d ≤ 15mm)
Θ	Impactor angle from horizontal

FIG. 16 SIDE ELEVATION OF THE MAIN FRAME WITH THE IMPACTOR

Dimensions and tolerances in millimetres

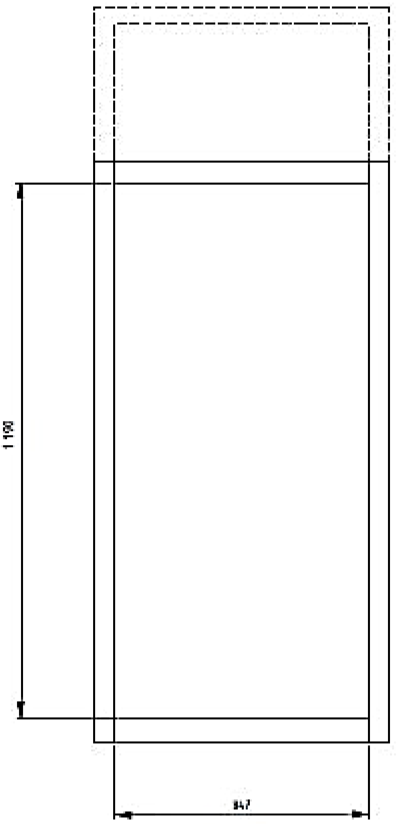


FIG. 17 DIMENSION OF THE FRONT ELEVATION OF THE FRAME

6.4.2.2 *Clamping frame*

Fitted on to the main frame and used to hold the test piece in position for the duration of the test, consisting of two rectangular parts which clamp the test piece along its perimeter (*see* Fig. 18). The inner part of the clamping frame is attached to the main frame.

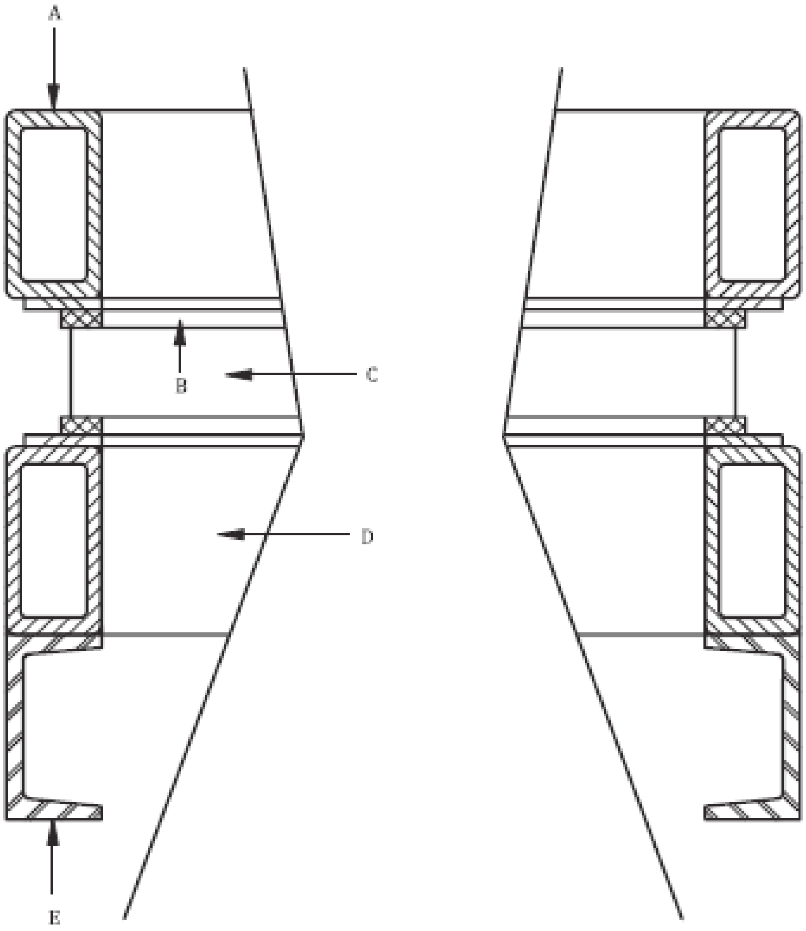
The assembly is held together by a clamping device. The clamping frame shall be suitably rigid to withstand the pressure exerted by the clamping device.

The dimensions of the clamping frame shall be as follows:

a) Internal width: (847 ± 5) mm;
b) Internal height: (1 910 ± 5) mm.

Each part of the clamping frame shall be fitted with a strip of rubber. The rubber strips shall be the only element in contact with the test piece and shall be 20 ± 2 mm wide and 10 ± 1 mm thick and have a hardness of 60 ± 5 IRHD.

NOTE — Polychloroprene or a similar material is suitable.



Key	
A	Clamping device, for example, ~ 100 mm × 50 mm × 8 mm
B	Rubber strip (20 ± 2) mm × (10 ± 1) mm
C	Test piece
D	Outer part of the main frame, for example, ~100 mm × 50 mm × 8 mm
E	Inner part of the main frame for example, ≤ 100 mm × 50 mm

FIG. 18 EXAMPLE OF CLAMPING OF THE TEST PIECE

6.4.2.3 *Impactor*

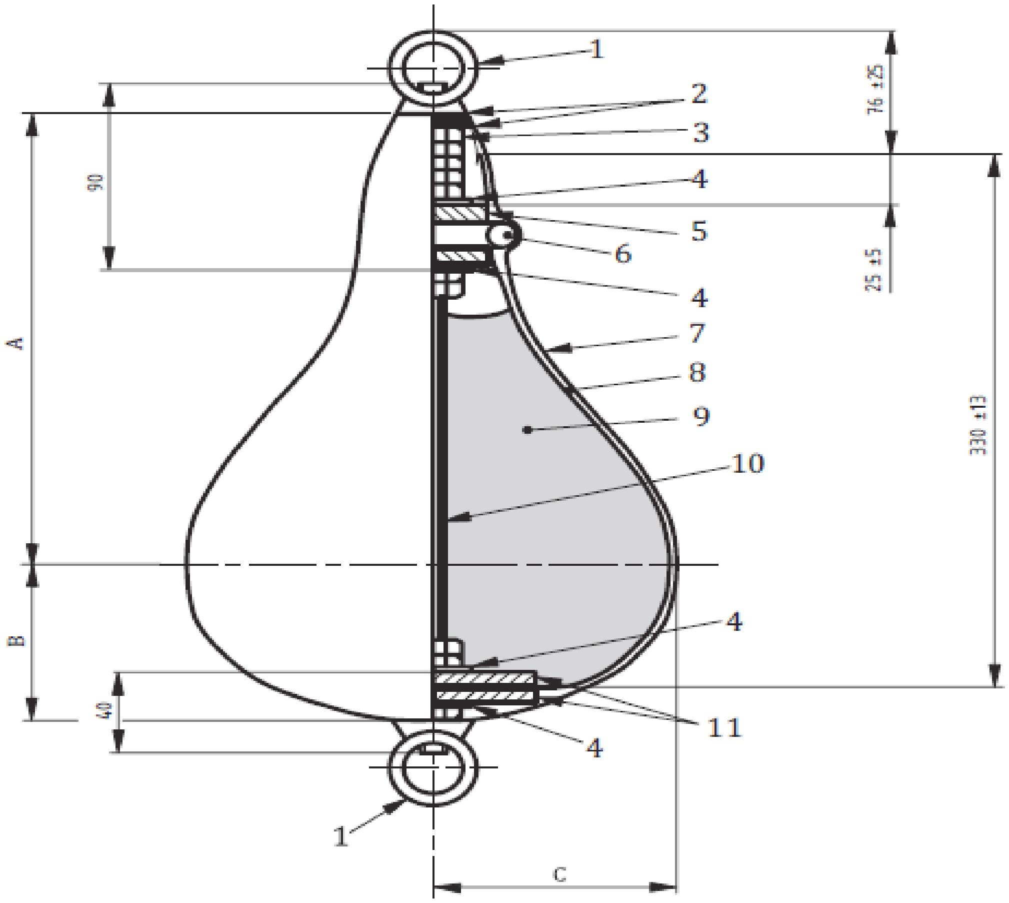
Impactor of type **6.4.2.4** or **6.4.2.5**, suitable for use with the suspension device (**6.4.2.6**) and release mechanism (**6.4.2.7**).

6.4.2.4 *Lead shot bag*

- **a)** *General description* — The bag (*see* Fig. 19) is a reinforced leather bag filled with chilled lead shot of diameter 2.5 ± 0.1 mm providing a total mass of 45 ± 0.1 kg. The bag is constructed of 1.5 mm thick pliable leather (*see* Fig. 20).
- **b)** *Method of manufacture* **-** *see* ***6.4.6***.
- **c)** *Maintenance*

Inspect the shot bag impactor at intervals of 1 000 impacts and calibrate as required. If the tape of the impactor is damaged (for example, when glass fibres are apparent, or the leather bag is visible), it shall be removed and replaced according to **6.4.6**. When the deformation of the impactor is beyond the tolerances, the impactor shall be reshaped manually. If the impactor cannot be restored to within the tolerances, it shall be replaced.

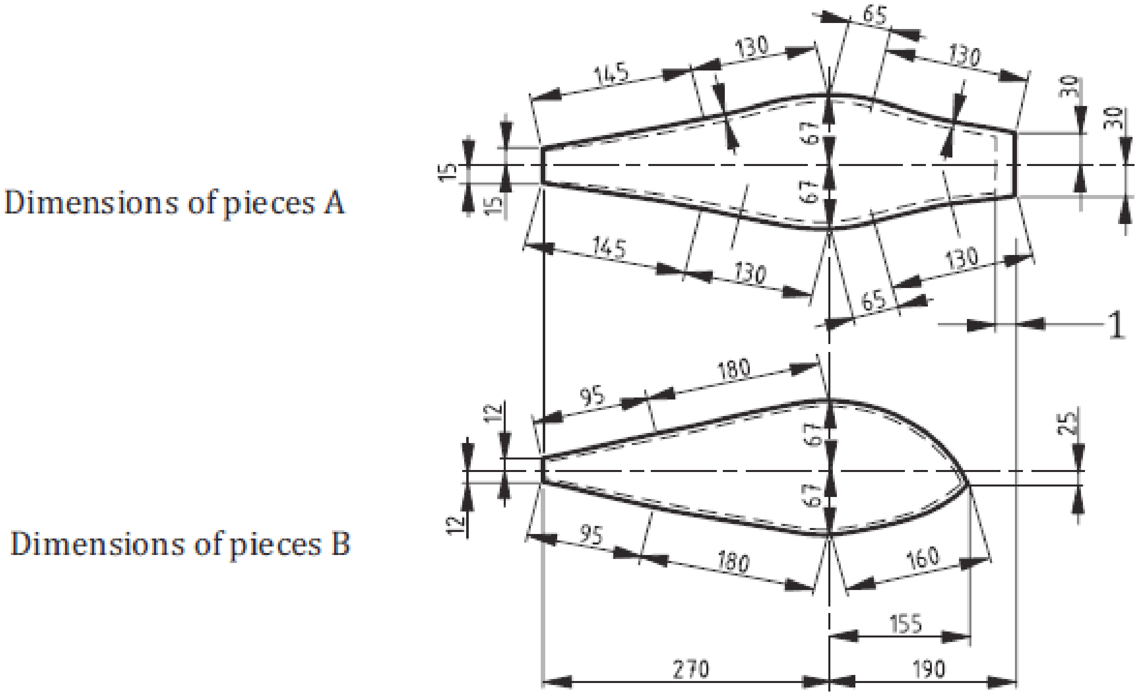
Remove all glass particles embedded in the surface of the impactor. The tolerances of dimensions for the impactor are shown in Fig. 19.



Key	Description	No. Required	Remarks
1	Eye nut	2	M 10
2	Plane washer	2	M 10
3	Hexagonal nut	10	M 10
4	Spring washer	4	M 10
5	Sleeve nut	1	Length: 25 mm; Diameter: 32 mm
6	Hose clamp	1	
7	Glass fibre-reinforced adhesive polyester tape	3 rolls	Width:12 mm; thickness: 0.15 mm
8	Leather bag	1	Synthetic leather
9	Lead shot	~ 45kg	Chilled shot, diameter: (2.5 ± 0.1) mm
10	Threaded metal rod	1	M 10 Length: 400 mm
11	Metal Washer	2	Thickness: 4.8 ± 1.6 mm: Diameter: 76 ± 3 mm

Fig. 19 Plan of Shot Bag Impactor

The leather bag may be made of synthetic leather of thickness 1.5 mm by seaming up with two sheets of piece A (*see* Fig. 20) and four sheets of piece B (*see* Fig. 20). The margin to seam between pieces A and B is about 4 mm.



Key

1 Margin to seam 16 mm

FIG. 20 DIMENSIONS OF PIECES OF SHOT BAG IMPACTOR

6.4.2.5 *Twin tyre impactor*

a) *General description*

Impactor consisting of two pneumatic tyres, for example, tyre 3.50-8/4PR3 or Continental T73, with round section and flat longitudinal tread (*see* Fig. 21). The tyres shall be fitted to the rims of the wheels that carry two equal steel masses. The masses shall be dimensioned so that the total mass of the impactor is 50 ± 0.1 kg.

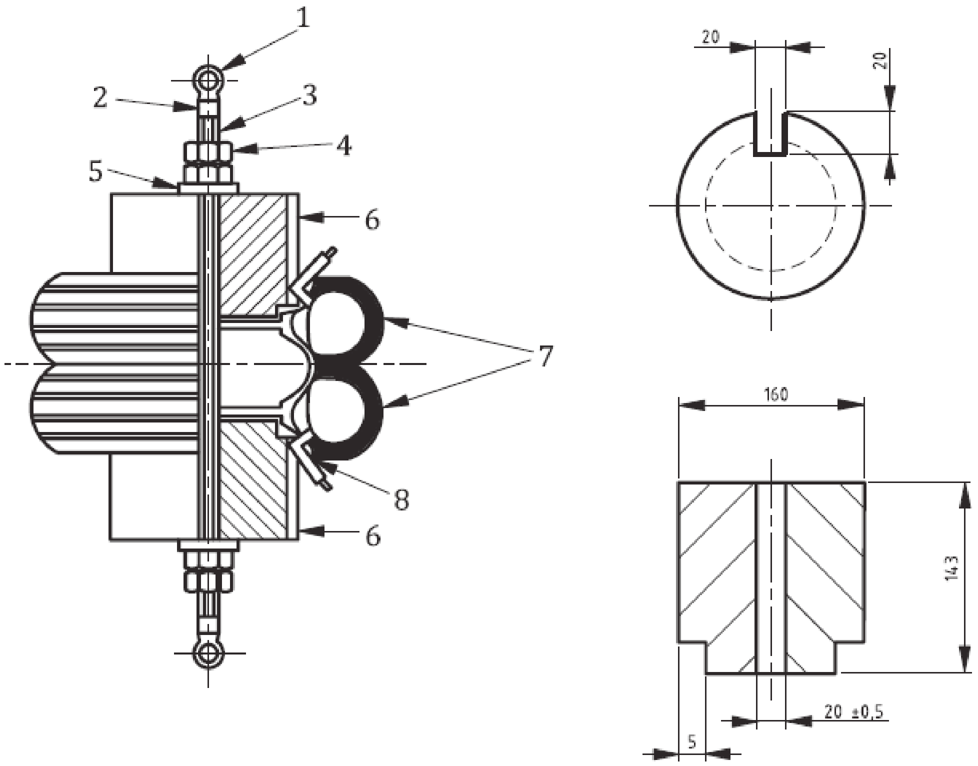
NOTE — The tyre specified for this impactor has been found to have performance variations dependent on site and country of manufacture. This variation can cause problems with the calibration, but has not been found to affect product classification.

b) *Method of manufacture*

An example of the impactor, using steel with a density of 7 830 kg/m^3, is shown in Fig. 21.

c) *Maintenance*

Check the air pressure in the tyres in accordance with **6.4.4**. Remove all glass particles embedded in the surface of the tyres. Inspect the state of the tyres regularly and replace when required.



a) plan

b) details of the mass

Key	Description	No. Required	Remarks
1	Eye bolt	2	M20
2	Hexagonal nut	2	M20
3	Screw spindle	1	M20; 45 mm
4	Hexagonal nut	4	M20
5	Collar	4	M20
6	Steel mass	2	*see* Fig. 21(b)
7	Pneumatic tyre	2	Tyre 3.50-8/4PR or Continental T73
8	Rim	2	250-8

FIG. 21 TWIN TYRE IMPACTOR

6.4.2.6 *Suspension device*

The impactor shall be suspended by means of a steel cable of diameter 5 mm from a bracket attached above the head of the main frame. The bracket shall be rigid to ensure that the point of suspension remains stationary during the test and shall be positioned to permit the impactor to strike the centre of the test piece.

At the highest drop height, the angle, θ, between the taut suspension cable and the bracket shall not be less than 14° (*see* Fig. 16).

When the impactor is hanging freely, at rest, the distance between the impactor and the surface of the test piece, D, shall not exceed 15 mm and shall not be less than 5 mm (*see* Fig. 16) and the centre of area of contact of the impactor shall be within 50 mm vertically and horizontally from the centre of the test piece.

6.4.2.7 *Traction and release system*

The impactor release mechanism enables the impactor to be raised and positioned at each of the specified drop height positions, and then to be released so that it swings freely and impacts the test piece. The release cable shall be connected to the top and bottom ends of the impactor by suitable links so that the raising force is applied at right angles to the axis of the impactor. The release mechanism shall ensure that the release cable is maintained at the correct orientation at each of the drop heights. An example of a release mechanism is given in **6.4.9**.

6.4.3 *Test pieces*

6.4.3.1 *General*

Each test piece shall comprise a single pane of glass product and be representative of the normal production of the type of product submitted for test.

6.4.3.2 *Dimensions of the test pieces*

The test pieces shall have the following dimensions:

a) Width: 876 ± 2 mm;

b) Height: 1 938 ± 2 mm.

Results obtained with test pieces of these dimensions are valid for classification purposes of the glass product whatever the service dimensions may be.

6.4.3.3 *Number of test pieces*

The test shall be carried out at each drop height prescribed in Table 3, preferably on four specimens (or a number representative of the lot size) of identical structure and the same nominal thickness. If the test pieces are of an asymmetric material, their number shall be doubled unless they are intended solely for installation in situations where the risk of impact is from one side only.

6.4.3.4 *Preparation of the test pieces*

Remove all masking and protection material from the test pieces and condition for a minimum period of 12 h at 27 ± 2**°C.**

6.4.4 *Impact test procedure*

Testing shall start at the lowest drop height (*see* Table 3) and increase up to the drop height appropriate to the class for which the material is intended (*see* **6.4.5.2**). The test shall be carried out at room temperature.

Place each test piece in the clamping frame so that its edges are encased in the rubber to a minimum depth of 10 mm. The test piece shall be firmly clamped within the sub-frame.

Use either a twin tyre impactor or shot bag impactor. When using the twin tyre impactor, inflate both impactor tyres to a pressure of 0.35 ± 0.02 MPa. Pressure shall be checked prior to testing and every 4 h after the start of the test. Its steel masses shall not make contact with the test specimen during the impact.

Raise the impactor to the lowest drop height (*see* Table 3) and stabilize. At the drop height, the suspension cable shall be taut, and the axis of the impactor and cable shall be in line (*see* Fig. 16).

Release the impactor so that it falls with a pendular movement and without initial velocity. The direction of impact on the centre of the test piece shall be normal to the surface. The impactor shall be allowed to strike the test piece only once.

For asymmetric materials that are intended for installation where the risk of impact is from both sides, carry out the test on both sides.

For asymmetric materials where the required classification is for one face only, solely the designated face shall be tested and this shall be reported in the test report.

Inspect the test piece after impact and note whether:

a) it remains unbroken,

b) it broke in accordance with either the requirements of **6.4.1.2** or **6.4.1.3,** or

c) it broke and failed to conform to the requirements of **6.4.1.2** or **6.4.1.3**.

If any of the initial test specimens (*see* **6.4.3.3**) fails to conform to the requirements of **6.4.1.2** or **6.4.1.3**, terminate the procedure. If all test specimens either do not break or else break according to the criteria given in **6.4.1.2** or **6.4.1.3**, and it is required by manufacturer to test the material to a higher impact level, increase the drop height to the next level (*see* Table 3) and repeat the test on another set of same number of samples of the same material.

If the material remained unbroken, the same sample(s) may be used.

6.4.5 *Classification*

6.4.5.1 *General*

Glass conforming to requirements of this test is classified in accordance with the following:

a) its performance under the impact test;

b) the drop height at which breakage occurred;

c) the drop height at which the product satisfied the specifications of **6.4.1.2**; and

Table 3 Impact Levels

Sl. No. (1)	Classification (2)	Lead Shot Bag (mm) (3)	Twin Tyre (mm) (4)
(i)	3	300	190
(ii)	2	450	450
(iii)	1	1 200	1 200

d) the drop height at which the product satisfied the specifications of **6.4.1.3**.

6.4.5.2 *Drop height class*

Glass shall be classified as follows:

a) Class 3 — Material that conforms to the requirements of **6.4.1.2** or **6.4.1.3** when tested by the method given in **6.4.4** at impact level classification 3 as per Table 3;

b) Class 2 — Material that conforms to the requirements of **6.4.1.2** or **6.4.1.3** when tested by the method given in **6.4.4** at impact level classifications 3 and 2 as per Table 3;

c) Class 1 — Material that conforms to the requirements of **6.4.1.2** or **6.4.1.3** when tested by the method given in **6.4.4** at all three impact levels as per Table 3.

6.4.5.3 *Mode of breakage*

If all test pieces remain unbroken at the drop height appropriate to its intended drop height class, the mode of breakage shall be determined and described as follows.

Type A — Numerous cracks appear forming separate fragments with sharp edges, some of which are large.

Type B — Numerous cracks appear, but the fragments hold together and do not separate.

Type C — Disintegration occurs, leading to a large number of small particles which are relatively harmless.

NOTE — The descriptions of the mode of breakage are intended to convey the following information:

a) Type A — mode of breakage typical of annealed glass;

b) Type B — mode of breakage typical of laminated glass and wired glass; and

c) Type C — mode of breakage typical of toughened glass.

6.4.5.4 *Performance classification*

The performance classification of a glass product shall be given as follows:

$\alpha(\beta)\varphi$

where,

α = highest drop height class (**6.4.5.2**) at which the product either did not break or broke in accordance with **6.4.1.2** or **6.4.1.3**;

β = mode of breakage; (*see* **6.4.5.3**); and

φ = highest drop height class (**6.4.5.2**) at which the product either did not break or when it did break, broke in accordance with **6.4.1.2**.

The retention criterion, φ, is met when no break occurs or numerous cracks appear, but no shear or opening is allowed within the test piece through which a (76 ± 1) mm diameter sphere can pass when a maximum force of 25 N is applied in accordance with **6.4.7**.

When a glass product breaks at a drop height of 190 mm with a double tyre impactor or 300 mm with a lead shot bag and the breakage is not in accordance with **6.4.1.2**, then the value of φ quoted shall be zero.

Example 1: A set of laminated glass test pieces were impacted with the following results:

a) at 190 mm/300 mm: three test pieces did not break while one test piece broke in accordance with **6.4.1.2**;

b) at 450 mm: all four test pieces broke in accordance with **6.4.1.2**; and

c) at 1 200 mm: all four test pieces broke and failed to comply with **6.4.1.2** or **6.4.1.3**.

Designated classification: 2(B) 2.

Example 2 : A set of thermally toughened soda lime silicate glass test pieces were impacted with the following results:

a) at 190 mm/300 mm: all four test pieces did not break;

b) at 450 mm: all four test pieces broke in accordance with **6.4.1.3**; and

c) at 1 200 mm: all four test pieces broke in accordance with **6.4.1.3**.

Designated classification: 1(C) 3.

Example 3 : A set of thermally toughened soda lime silicate glass test pieces were impacted with the following results:

a) at 190 mm/300 mm: two test pieces did not break and two test pieces broke in accordance with **6.4.1.3**;

b) at 450 mm: all four test pieces broke in accordance with **6.4.1.3**; and

c) at 1 200 mm: all four test pieces broke in accordance with **6.4.1.3**.

Designated classification: 1(C) 0.

6.4.6 *Method of Fabrication of the Shot Bag Impactor*

6.4.6.1 Fig. 19 shows all the materials required for fabricating a shot bag (also called leather bag) along with the respective dimensions. The dimensions indicated on the right side of Fig. 19 are those specified in this standard. The dimensions indicated on the left side of Fig. 19 are those required for fabricating a shot bag. A shot bag compliant with this standard can be fabricated by placing the upper double nut positioned at 90 mm from the top of the bag and the lower double nut positioned at 40 mm from the bottom of the bag.

6.4.6.2 Before starting, loosen the strap of the leather bag and remove the internal rubber bag.

6.4.6.3 At the hanging strap position of the bag, provide a hole with a knife in a size to allow a threaded metal rod of diameter 10 mm to pass through.

6.4.6.4 Install eye nut and plain washer together with nut at about 90 mm from the upper end of the threaded metal rod to form a double nut (for locking) and fix them securely in place. Then install four nuts fastening them retrospectively. Next, install a spring washer and a sleeve nut.

6.4.6.5 At 40 mm from the other end of the threaded metal rod, form a double nut using hexagonal nut to fix the rod in place. Install a spring washer and metal washer and thrust the rod through the centre of the bottom of the leather bag from inside.

6.4.6.6 Install metal washer and spring washer on the threaded metal rod extruding out of the bottom of the leather bag, fasten with a hexagonal nut forming a double nut in combination with an eye nut, and fix the rod in place. (For safety during testing, if the end of the threaded metal rod does not extrude from the eye nut due to any thickness error with the metal or spring washers, change the distance from the end from 40 mm to 45 mm and repeat steps **6.4.6.5** and **6.4.6.6**).

6.4.6.7 At the other end of the rod, install plain washer and thrust the rod through the hanging strap. Install another plain washer, then, fasten with eye nut. (As in **6.4.6.6**, if the end of the rod does not extrude through the eye nut, change the distance from the upper end from 90 mm to about 95 mm and redo steps **6.4.6.3** to **6.4.6.6**). The five nuts above sleeve nut and plain washer are to hang the leather bag following the specified dimensions.

6.4.6.8 Fix the lace of the leather bag from the bottom up to about half of the total lacing length.

6.4.6.9 Place the leather bag (as in **6.4.6.8**), three rolls of tape, and hose clamp on a spring balance, then fill the bag with lead shots until the mass of the total assembly reaches 45.0 ± 0.1 kg.

6.4.6.10 Fix the remaining lace, and fasten the sleeve nut section of the leather bag neck with hose clamp.

6.4.6.11 Hang the completed leather bag with a rope from the ceiling or other elevated section.

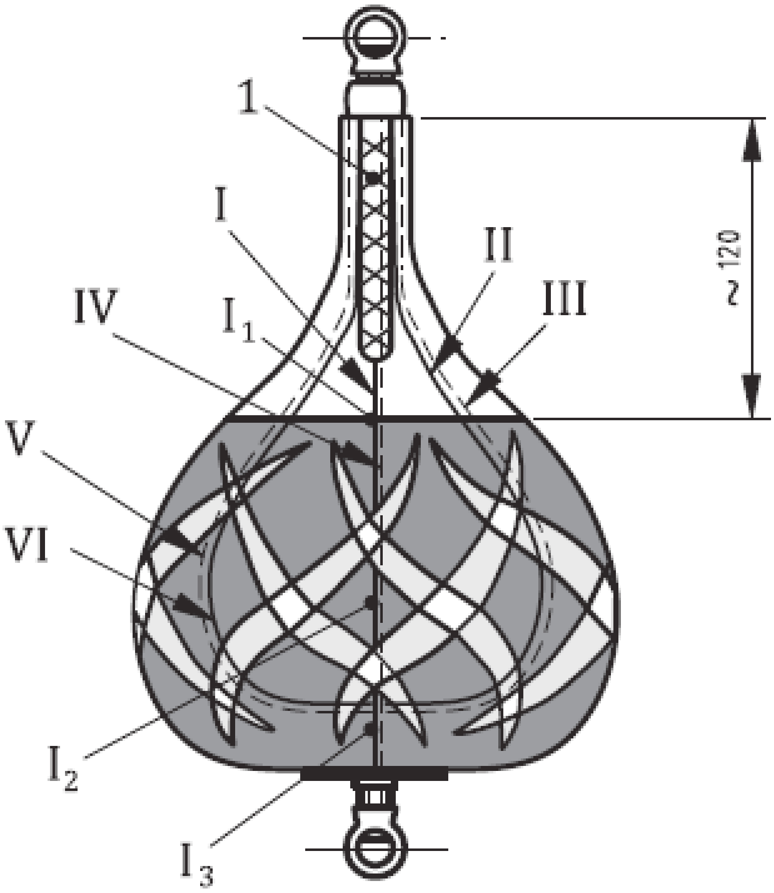
6.4.6.12 Tape the leather bag to cover its entire surface using three rolls of the specified type of tape in diagonal, overlapping manner. Tape the neck section separately. (The "neck" refers to the section extending from the top of the bag to about 120 mm downward.)

The detailed taping procedure is described from **6.4.6.13** to **6.4.6.26**.

6.4.6.13 Shape the lifted bag properly by tapping with the hand.

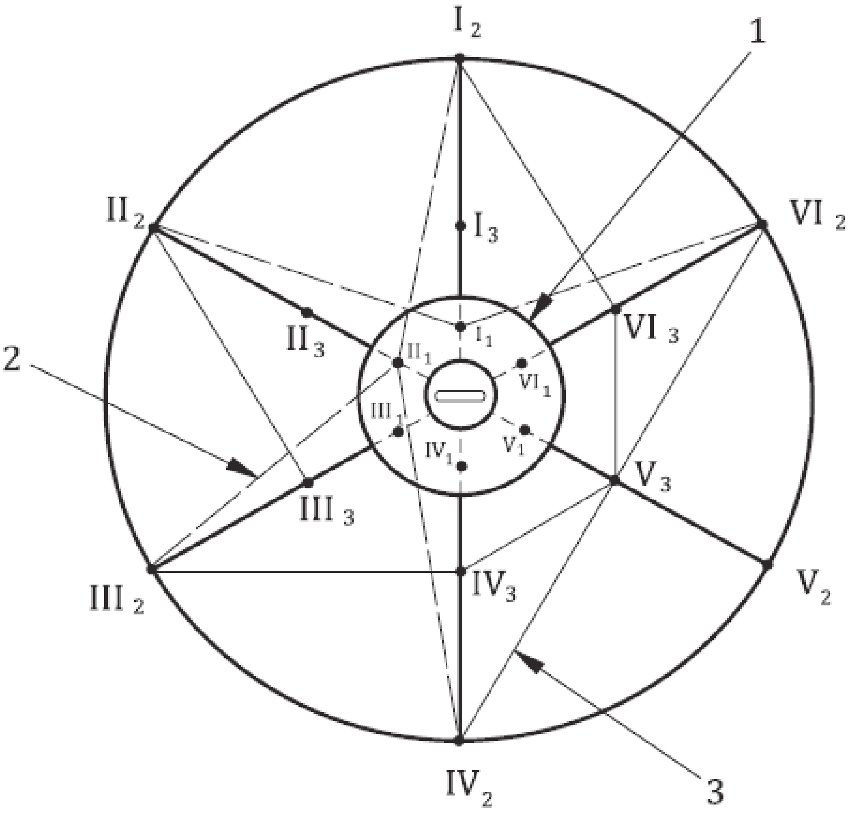
6.4.6.14 Measure the circumference of the section where the diameter is the maximum and calculate the diameter. The maximum diameter shall be about 250 mm. (If the maximum diameter significantly deviates from the specified value, there is no way to correct it. In that case, the only solution is probably to replace the bag with another one or remake the shot bag.)

6.4.6.15 Assign code I to the leather seam on which the lace is located. Assign codes II, III, IV, V and VI to the other seams counter clockwise from code I (*see* Fig. 22 and 23).



Key	
1	Lace
I	Seam 1 (Includes lace)
II	Seam 2
III	Seam 3 (at the back of the bag)
IV	Seam 4 (at the back of the bag)
V	Seam 5 (at the back of the bag)
VI	Seam 6
I_1	Taping point 1 on seam 1 (at base of neck portion, 30mm from lace portion
I_2	Taping point 2 on seam 1 (at maximum circumference)
I_3	Taping point 3 on seam 1 (30 mm outside the metal washer)

FIG. 22 SIDE ELEVATION OF SHOT BAG (TAPING POINTS ARE ONLY SHOWN ON SEAM BUT THEY ARE ON ALL SEAMS)



Key	
1	Metal washer
2	Example taping lines on upper part of bag
3	Example taping lines on lower part of bag
I_1, II_1, III_1, IV_1, V_1, VI_1	Upper taping points 1(30mm below lace) on seams I – VI
I_2, II_2, III_2, IV_2, V_2, VI_2	Middle taping points 2(fat maximum circumference) on Seams I-VI
I_3, II_3, III_3, IV_3, V_3, VI_3	Lower taping points 3 (30mm outside the metal washer) on Seam I – VI

FIG. 23 PLAN OF SHOT BAG FROM BELOW

6.4.6.16 As shown in Fig. 22 and 23, assign code I_1 to the section about 30 mm below the lower end of the lace section, code I_2 to the section with the maximum diameter, code I_3 to the section about 30 mm outside the metal washer. In the same manner, assign code II_1, II_2, II_3, III_1, III_2, and III_3 and so on through VI_1, VI_2 and VI_3 in sequence.

6.4.6.17 Start taping at I_1 by applying it diagonally at an angle of 45° to reach point III_3 via point II_2. The tape should be lightly extended without any strain on it. Cut the tape at point III_3.

6.4.6.18 In the same manner, apply the tape lightly, without strain, to cover points II_1, III_2 and IV_3; III_1, IV_2 and V_3; IV_1, V_2 and VI_3; V_1, VI_2 and I_3; and VI_1, I_2 and II_3, cutting the tape at the end of each sequence.

6.4.6.19 Next, slant the tape by 45° in the opposite direction and tape the bag, covering I_1, VI_2 and V_3; II_1, I_2 and VI_3; III_1, II_2 and I_3; IV_1, III_2 and II_3; V_1, IV_2 and III_3; and VI_1, V_2 and IV_3 in the same manner as in **6.4.6.17** and **6.4.6.18**.

6.4.6.20 Around the tape applied (**6.4.6.19**), apply the tape in two rows on the right and left sides, completing two fold taping in total of five rows, also without strain.

Fig. 22 shows the view as taping is completed to this point. The sections shaded in darker grey are where the tape is applied in five rows and overlapped in four layers while the sections shaded in lighter grey where the tape is applied in two fold five rows.

The following are three tips on taping:

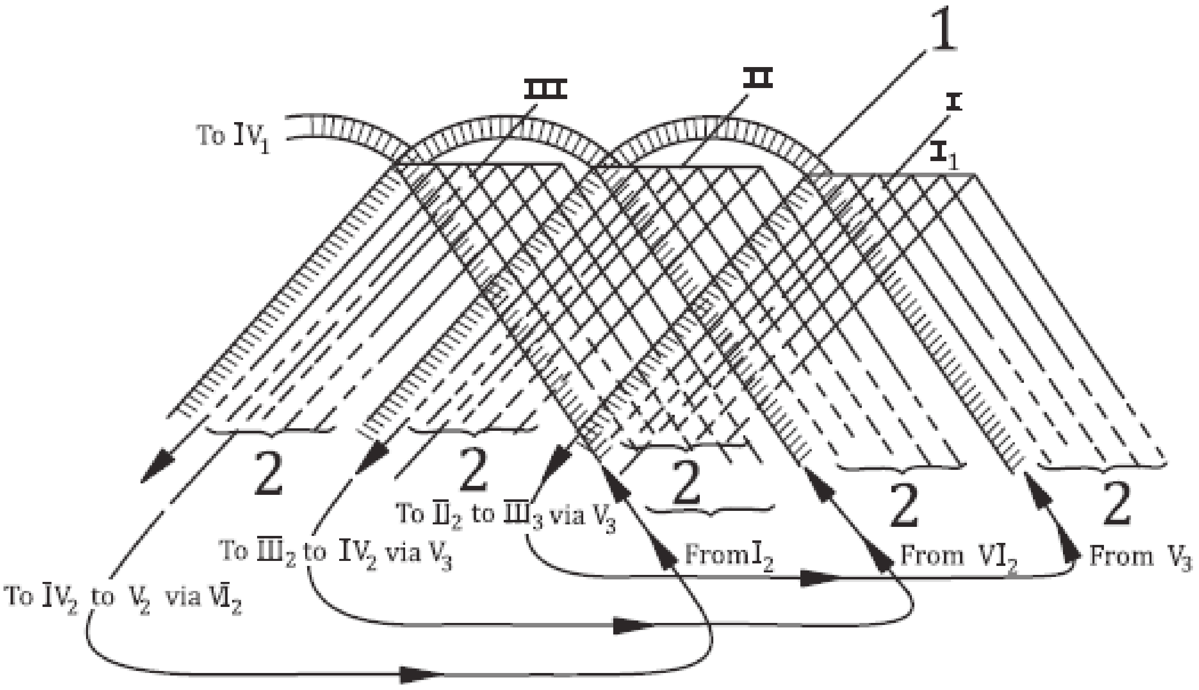
a) Avoid neighbouring rows overlapping when carrying out twofold taping in five rows. Overlapping causes wrinkles. In particular, the upper and lower sections of the respective rows can easily overlap. If this happens, tape locations cannot be correctly recognized in the subsequent steps.

b) Do allow the tape to be put under strain. Strain hardens the bag.

c) Ensure that tapes cross at the section where the diameter is greatest.

6.4.6.21 Next, shift the tape by half its width and apply it continuously, without cutting it, to achieve twofold taping in five rows. Start at point I_1 to pass through points II_2, III_3, IV_3, V_3, VI_2, I_1, in this order (*see* Fig. 23). Force the tape to be redirected at the bottom of the bag to apply it from point III_3 to point V_3 via IV_3. (Wrinkles are permitted in doing so.) Then, turn the taping direction to allow taping from point V_3 to point I_1 via point VI_2 (*see* Fig. 24).

6.4.6.22 From point I_1 where taping ended in the previous step, extend it (wrinkles permitted) to pass through II_1, III_2, IV_3, V_3, VI_3, I_2 and II_1 (*see* Fig. 24). In the same manner, apply the tape to cover III_1, IV_2, V_3, VI_3, I_3, II_2 and III_1; IV_1, V_2, VI_3, I_3, II_3, III_2 and IV_1; V_1, VI_2, I_3, II_3, III_3, IV_2 and V_1; VI_1, I_2, II_3, III_3, IV_3, V_2 and VI_1, then return to I_1. Then repeat the same procedure again to achieve twofold taping (*see* Fig. 24).


1
III
II
I
I_1
To IV_1
2
2
2
2
2
To II_2 to III_3 via V_3
To III_2 to IV_2 via V_3
To IV_2 to V_2 via VI_2
From I_2
From VI_2
From V_3

Key	
1	Starting point (Shift the tape by half a width)
2	Five rows two fold

FIG. 24 TAPING METHOD

6.4.6.23 As **6.4.6.22** is completed, the tape returns to point I_1. Next, shift the tape to the right, and follow **6.4.6.21** and **6.4.6.22** to perform the same procedure and achieve two-fold taping in five rows (never strain the tape and apply it carefully in five rows).

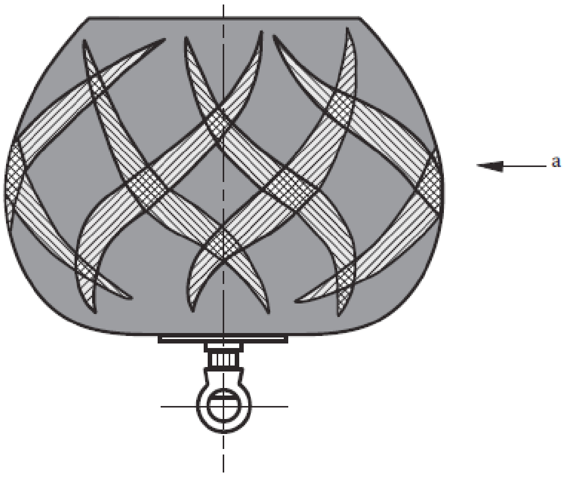
When the steps above are completed, taping is completed in eight folds in five rows over the sections shaded darkly in Fig. 22 and in the lighter-shaded sections, in four folds in five rows.

6.4.6.24 Reinforce the sections shown in white and the light grey shaded areas in Fig. 22 so that taping is achieved in eight folds. To reinforce, apply the tape in four folds and in several rows so that it crosses at the section where the diameter is the greatest. Now the tape is applied in eight folds over the white sections and light grey sections (*see* Fig. 25).

6.4.6.25 As it is specified that the body and neck sections be taped separately, start taping for the neck portion below the upper eye nut to proceed in a spiral manner downward by shifting the tape by half its width until the tape reaches the lace section. (Apply taping until the tape becomes flush with the point already taped in the previous steps up to **6.4.6.24**.) The "neck" refers to the portion extending from the top of the bag to about 120 mm below (*see* Fig. 22).

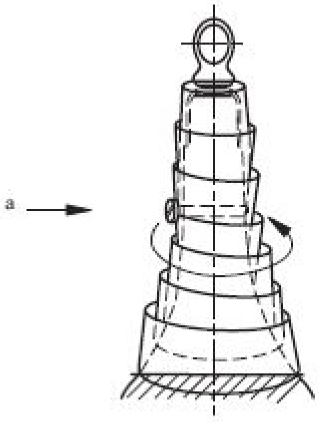
Taping in a spiral manner causes part of the tape to be not in contact with the bag as shown in Fig. 26. Apply pressure to these parts of the tape so that contact with the bag is established. Repeat this operation four times to achieve taping in eight folds.

6.4.6.26 Apply the remaining portion of the tape at random points with allowance given for retention of the tape used for reinforcement so that the tape is evenly applied.



Key	
a	Applying the tape in four folds over the white and light grey section achieves taping at the intersection in eight folds

FIG. 25 TAPING REINFORCEMENT



Key	
a	Apply the tape in a spiral manner overlapping by half its width

FIG. 26 TAPING IMPACTOR NECK (VIEW WHEN TAPING IS COMPLETED AROUND)

6.4.7 *Sphere Penetration Test*

6.4.7.1 *Probe assembly*

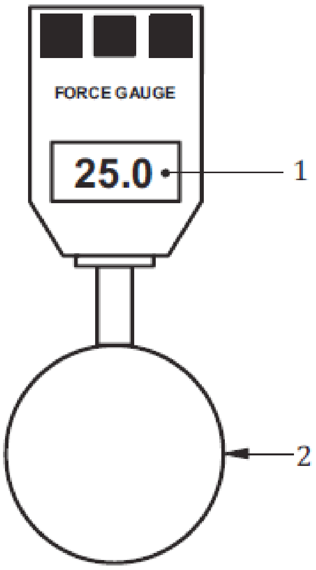
The probe assembly shall consist of a sphere of diameter 76 ± 1 mm connected to an arm with a device for measuring when a maximum force of 25 N has been applied. An example of a probe assembly is shown in Fig. 27.

6.4.7.2 *Operation*

The probe assembly shall be held so that it is horizontal. It shall then be pushed into any opening formed in the test piece after impact test. The weakest point of resistance shall be selected. A horizontal force shall be applied until either:

a) a maximum force of 25 N has been achieved without penetration by the sphere (the test piece shall be deemed to have passed the test); or

b) the maximum diameter of the sphere has passed through the plane of the test piece without a force of 25 N being achieved (the test piece shall be deemed to have failed the test).



Key	
1	Force indicated in Newtons
2	76 mm Diameter sphere

FIG. 27 EXAMPLE OF A PROBE TO VERIFY FREE PASSAGE OF A 76 MM DIAMETER SPHERE

6.4.8 *Example of Test Rig*

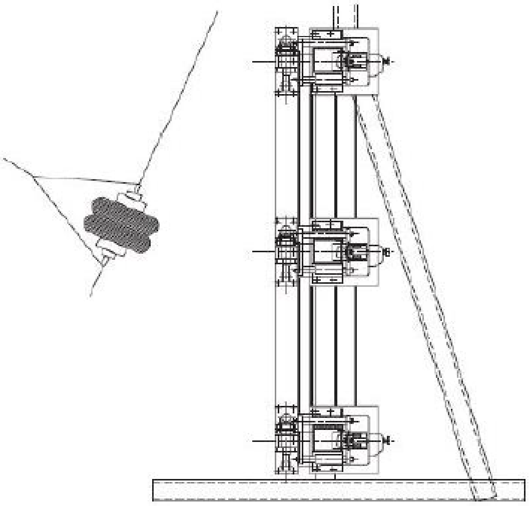
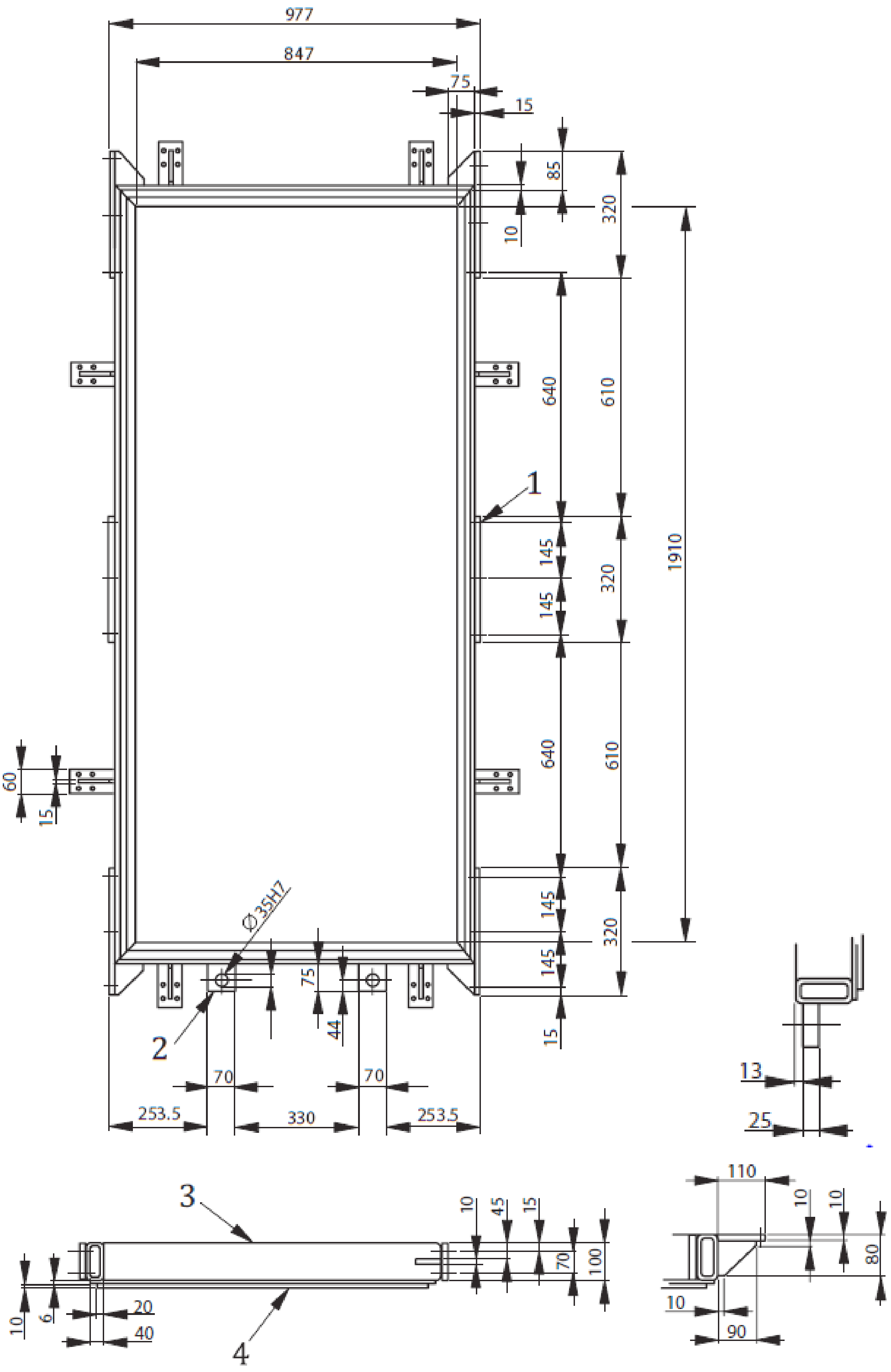
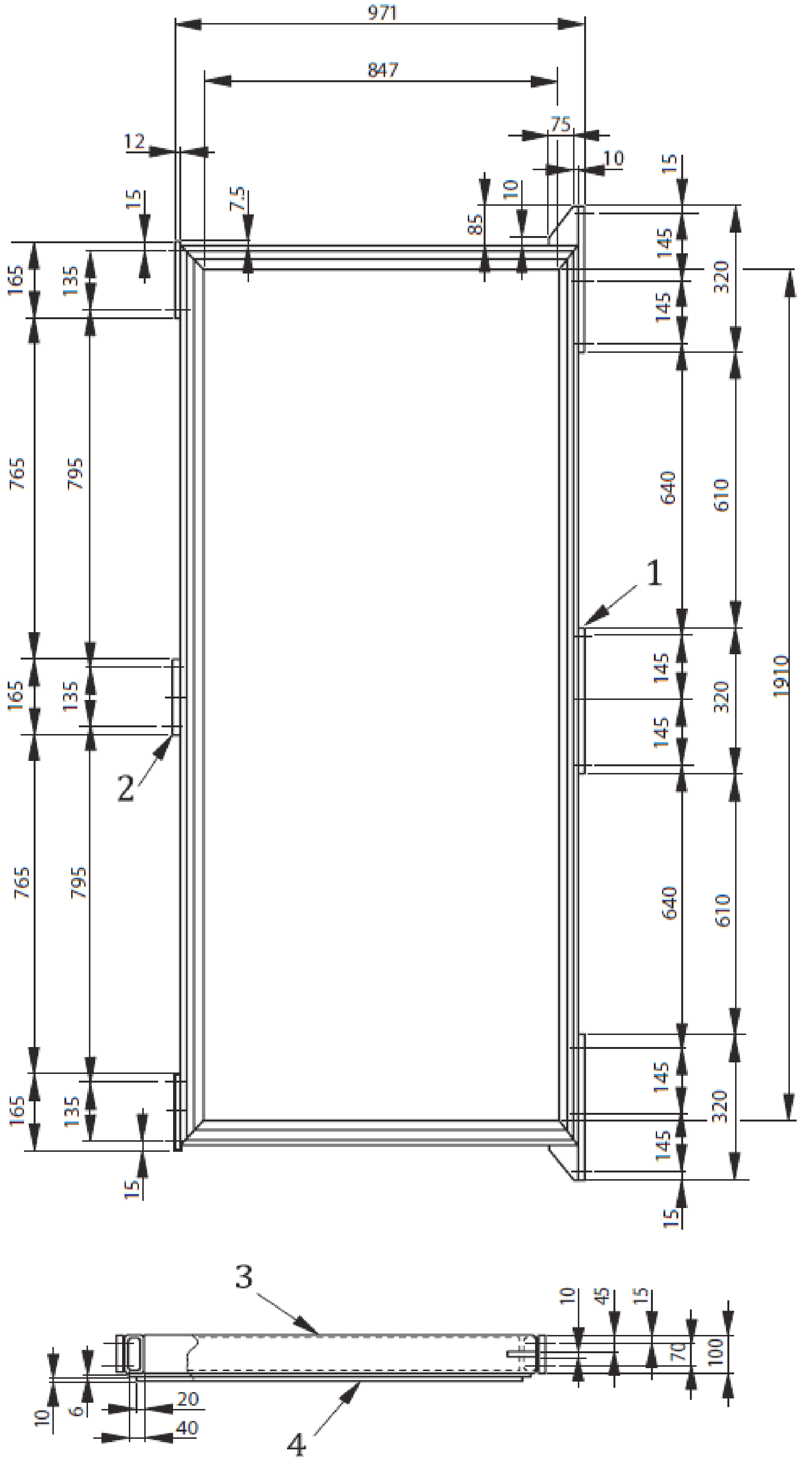


FIG. 28 SIDE ELEVETION OF THE MAIN FRAME WITH THE IMPACTOR



Key	
1	12 holes ø M12
2	See detail
3	100 × 50 × 8 right hand side
4	Rubber strips 20 × 10

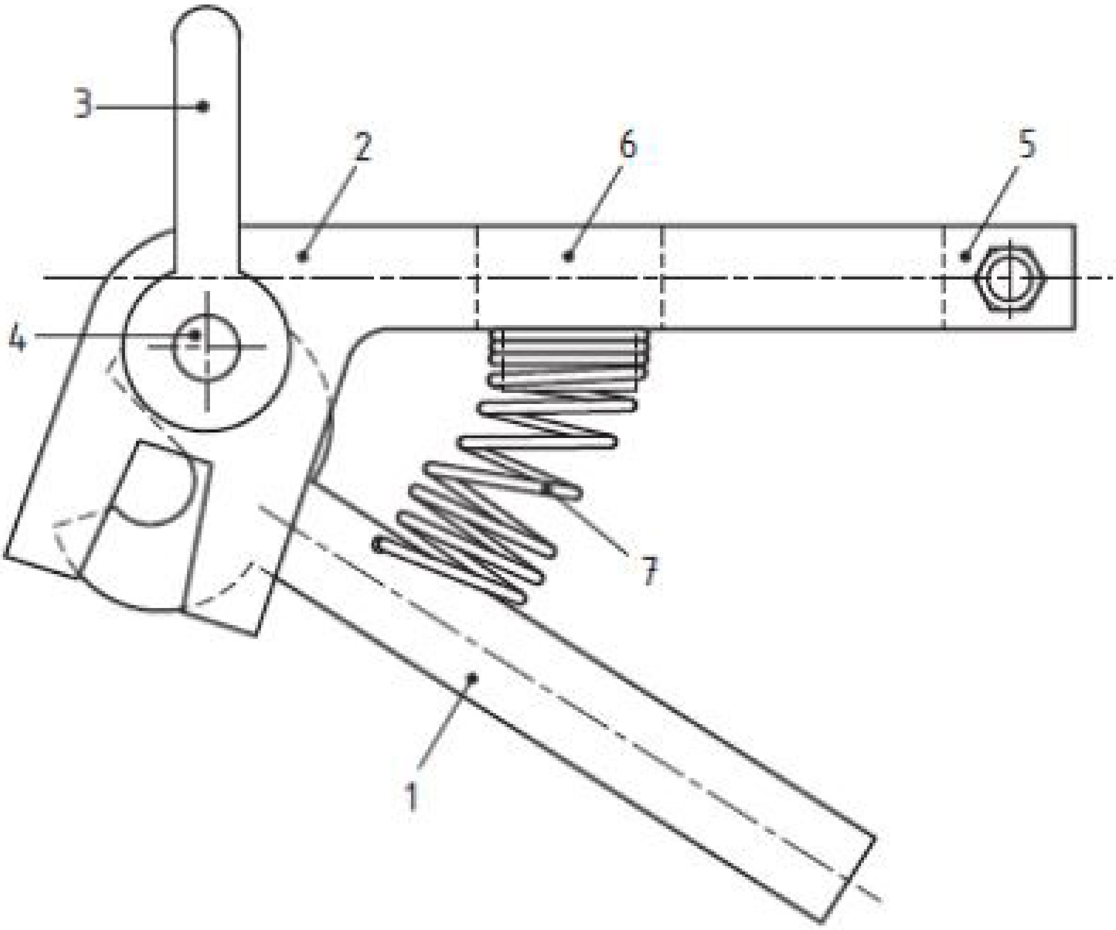
Fig. 29 Component No.1



Key	
1	18 holes ø M12
2	12 holes ø M12
3	100 × 50 × 8 right hand side
4	Rubber strips 20 × 10

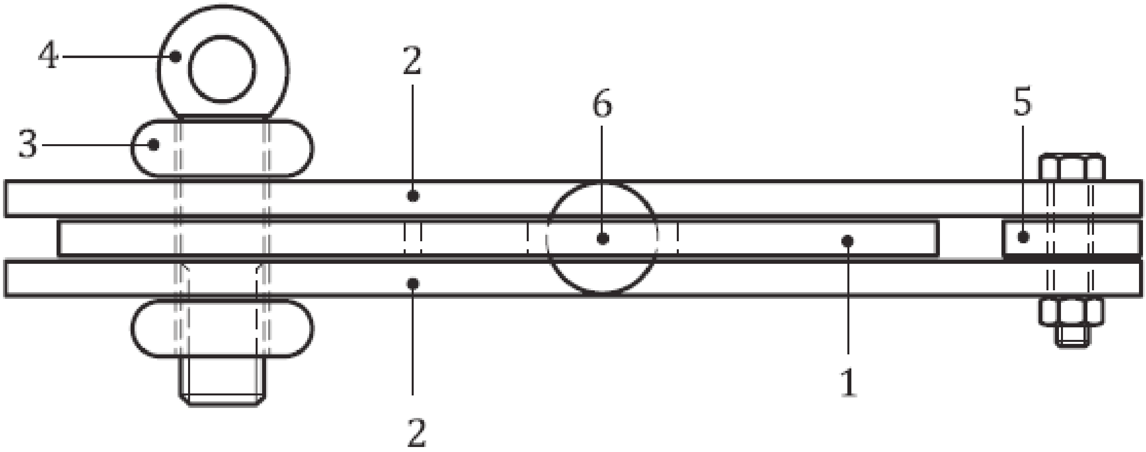
FIG. 30 COMPONENT NO.2

6.4.9 *Example of Release Mechanism*



Key	
1	Component 1
2	Component 2
3	Component 3
4	Component 4
5	Component 5
6	Component 6
7	Component 7

FIG. 31 EXAMPLE OF RELEASE MECHANISM VIEW 1



Key	
1	Component 1
2	Component 2
3	Component 3
4	Component 4
5	Component 5
6	Component 6
7	Component 7

FIG. 32 EXAMPLE OF RELEASE MECHANISM VIEW 2

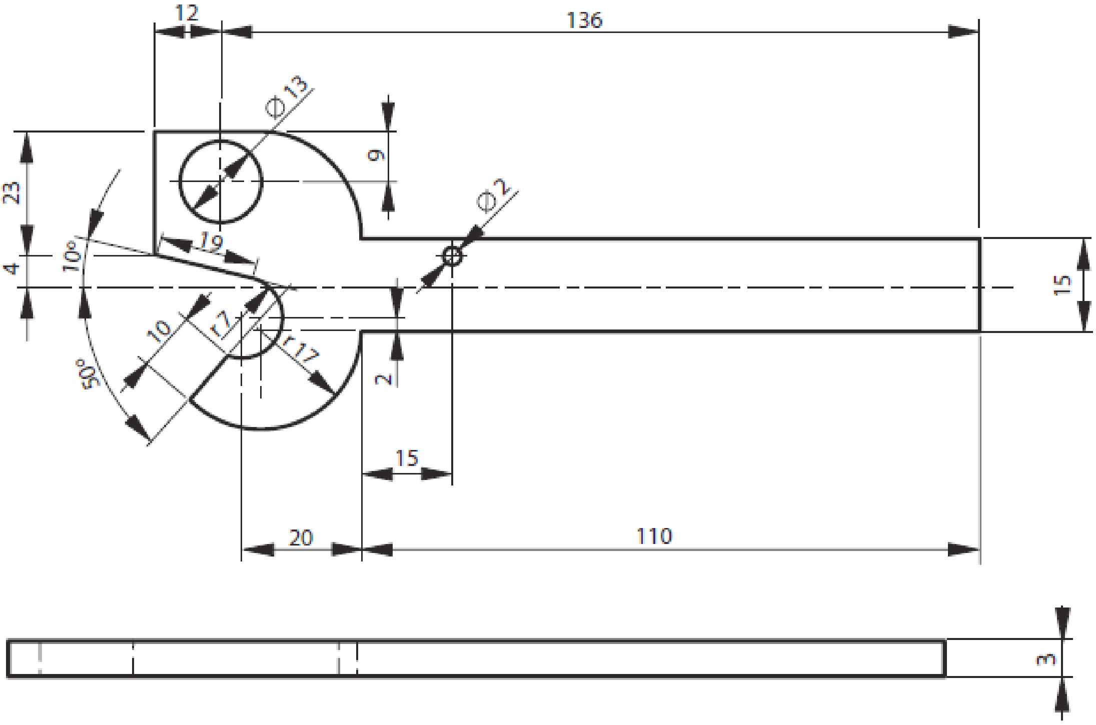


FIG. 33 COMPONENT NO.1

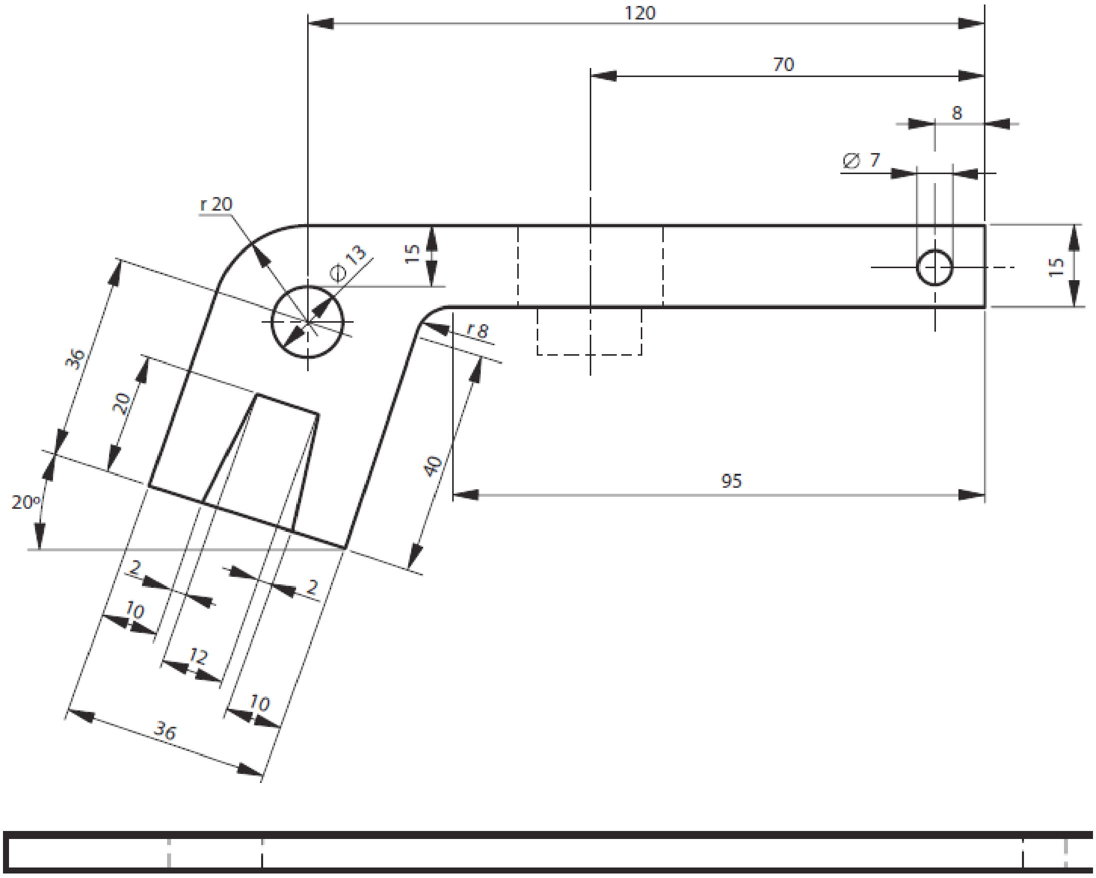


FIG. 34 COMPONENT NO. 2

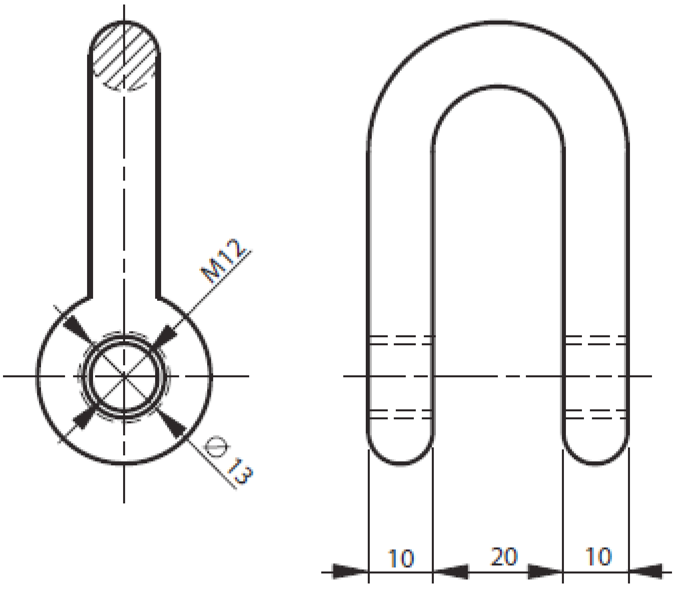


FIG. 35 COMPONENT NO. 3

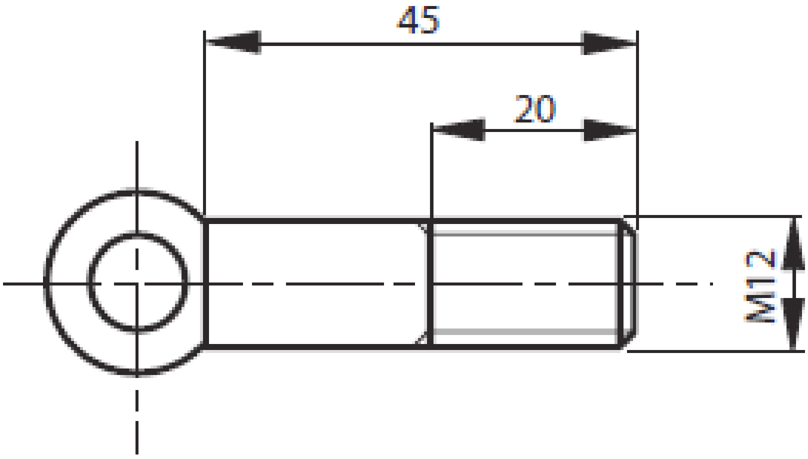


FIG. 36 COMPONENT NO. 4

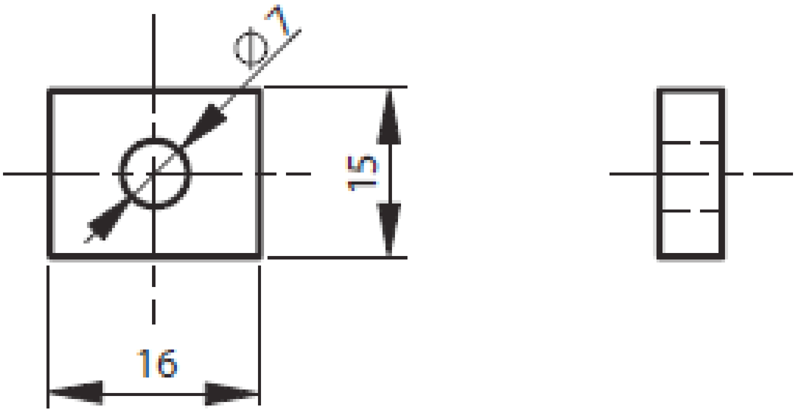


FIG. 37 COMPONENT NO. 5

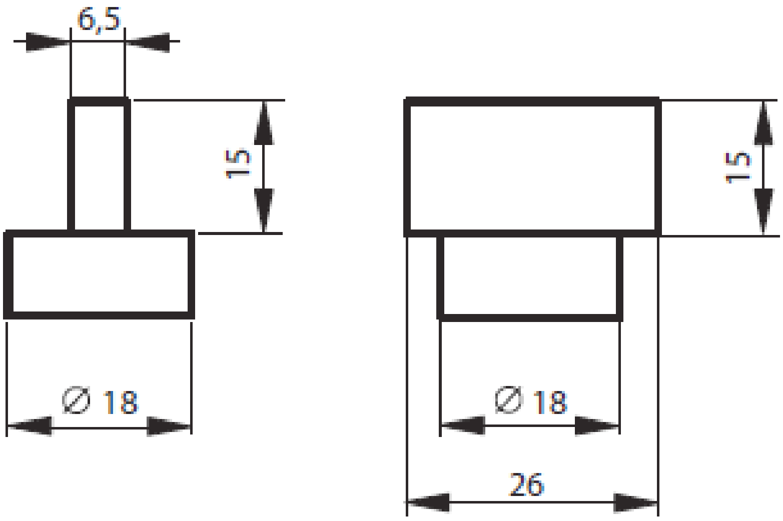


FIG. 38 COMPONENT NO. 6

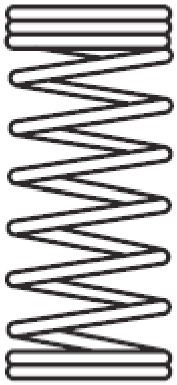


FIG. 39 COMPONENT NO. 7

6.5 Surface Compression Test

6.5.1 *General*

During heat treatment process of the glass, stress is induced at the edge and surface of the glass which affects its performance/strength. The test method prescribed for measuring the edge stress and surface stress is applicable to light transmitting glasses since the method uses transmitted light, and is non-destructive in nature. The prescribed test method is not applicable to chemically tempered glass and is suitable to measure surface stress only on 'tin' side of float glass.

The test method is based on the concept of photo-elasticity. Upon the application of stresses, photo-elastic materials exhibit the property of birefringence, and the magnitude of the refractive indices at each point in the material is directly related to the state of stresses at that point.

Note — Information such as maximum shear stress and its orientation may be determined by analyzing the birefringence with an instrument called a polariscope.

When a ray of light passes through a photo-elastic material, its electromagnetic wave components are resolved along the two principal stress directions and each component experiences a different refractive index due to the birefringence. The difference in the refractive indices leads to a relative phase retardation between the two components. This relative retardation is proportional to the stress.

6.5.2 *Equipment*

A suitable commercially available equipment using polariscopic method may be used.

6.5.3 *Measurement*

Six samples of size not less than 360 mm × 1 100 mm shall be used for this test. Measurement shall be performed following the particular instructions of the device manufacturer. The stress measurement shall be taken on five points as indicated in Fig. 40. Each measurement shall be reported individually for the sample. The measured surface stress shall be calculated and expressed in MPa.

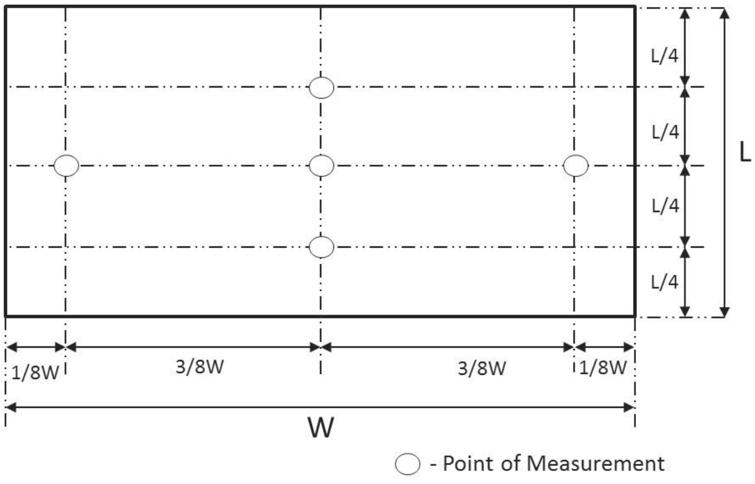


FIG. 40 POINTS TO BE MARKED FOR SURFACE COMPRESSION MEASUREMENT

7 TEST FOR DURABILITY

7.1 High Temperature Test

7.1.1 *Boil Test*

Three samples of size not less than 300 mm × 300 mm shall be tested.

Test samples should be placed in hot water at 60°C for 10 min before transferring/increasing the temperature to 100°C, in order to avoid thermal breakage in boiling water.

Maintain the temperature of the boiling water at 100^{+0}_{-2} °C for two h.

NOTE — The specimens shall be kept in the vessel of boiling water in such a way as not to touch the bottom of the testing vessel directly. A suitable arrangement may be used.

The specimens shall be taken out and allowed to cool to room temperature by storing them vertically under natural convection and radiation. The assessment of the test sample maybe carried out when the glass surface temperature is lower than 30°C.

7.1.1.1 *Interpretation of results*

The samples shall be inspected at a distance between 300 mm and 500 mm in front of a white diffused background and the number and extent of the faults occurring in the test specimens shall be recorded. Faults include bubbles, delamination, haziness and clouding, but not discolouration. All faults falling within 15 mm from an original edge and 20 mm from a cut edge of the specimen may be disregarded. In case of wired glass, individual bubbles in the immediate vicinity of inlaid wires are permissible. Specimen showing cracks shall be disregarded and the test shall be performed on a new set of sample from the same batch.

7.1.2 *Bake Test*

Three samples of size not less than 300 mm × 300 mm shall be tested. The high temperature test shall be carried out using a hot air oven capable of maintaining

100 ± 2°C.

The specimens shall be heated to 100°C and maintained for a period of 2 h. The specimens shall be taken out and allowed to cool to room temperature by storing them vertically. The assessment of the test sample maybe carried out when the glass surface temperature is lower than 30°C.

The samples shall be inspected at a distance between 300 mm and 500 mm in front of a white diffused background and the number and extent of the faults occurring in the test specimens shall be recorded. Faults include bubbles, delamination, haziness and clouding, but not discolouration. All faults falling within 15 mm from an original edge and 20 mm from a cut edge of the specimen may be disregarded. In case of wired glass, individual bubbles in the immediate vicinity of inlaid wires are permissible. Specimen showing cracks shall be disregarded and the test shall be performed on a new set of sample from the same batch.

7.2 Humidity Test

7.2.1 Two pairs of three samples of size not less than 300 mm × 300 mm shall be used for the test. Adequate spacing between the specimens placed inside the humidity chamber must be ensured. The samples shall be subjected to the following cycle of environmental conditions.

7.2.1.1 *With condensation*

Three samples shall be placed vertically in the humidity chamber for 2 weeks, at 50 + 5°C and 100 percent relative humidity.

Note — Humidity test with condensation is more applicable to laminated glass made out of folio/sheet interlayer.

7.2.1.2 *Without condensation*

Three samples shall be placed vertically in the humidity chamber for 2 weeks, at 50 + 5°C and 80 ± 5 percent relative humidity.

Note — Humidity test without condensation is more applicable to laminated glass made out of intumescent interlayer.

7.2.2 *Interpretation of Results*

Inspect the samples at a distance between 300 mm and 500 mm in front of a white diffused background. The number and extent of the faults occurring in the interlayer (bubbles, delamination, haze and cloudiness) should be noted. All faults falling within 15 mm from an original edge, 20 mm from a cut edge of a specimen or 10 mm from any crack shall be disregarded. In case of wired glass, individual bubbles in the immediate vicinity of inlaid wires are permissible. In the case of fire-resistant laminated glass, only delamination shall be considered as a fault.

Note — Fire resistant laminated glass and fire resistant laminated safety glass may create bubbles and cloudiness in the interlayer due to exposure to the high temperature reached during the test. This does not affect the fire resistant properties and therefore only delamination needs to be considered.

7.3 Radiation Test

7.3.1 *Radiation Source*

Medium-pressure mercury vapour arc lamp with a tubular quartz bulb (ozone-free type) shall be used as radiation source. The bulb axis shall be vertical. The nominal dimensions of the lamp shall be 360 mm in length and 9.5 mm in diameter. The arc length shall be 300 ± 4 mm. The lamp shall operate at 750 ± 50 W. Any other source of radiation that produces the same effect as a medium-pressure mercury vapour arc lamp may be used. To check whether the effects of another radiation source are similar, a comparison shall be made by measuring the amount of energy emitted within a wavelength range of 300 nm to 450 nm, all other wavelengths being removed by the use of suitable filters. The alternative source shall then be used with these filters.

7.3.2 *Procedure*

Three test samples of size not less than 300 mm × 300 mm shall be used and the luminous transmittance of the specimen shall be checked before subjecting them to exposure (*see* **7.6.2.2 and 7.6.2.3**). The test specimens shall be so oriented that, if there is a designated outer surface, it faces the lamp array. Asymmetric laminated glass, which does not have a designated outer surface, shall be tested on both sides. The test specimen shall be placed 230 mm from and parallel lengthwise to the lamp axis and maintained at 45 ± 5°C. The exposure time for the radiation test shall be

2 000 h. The luminous transmittance of each test specimen shall be tested again after exposure.

7.3.3 *Expression of Results*

If the initial light transmittance of the test specimen was > 65 percent, compare the results of the luminous transmittance measurement of each exposed test specimen with the values obtained for the same test specimen before exposure and express the deviation as a percentage. If the initial luminous transmittance was < 65 percent, report the difference between initial and final light transmittance.

Inspect the samples at a distance between 30 cm and 50 cm in front of a white diffuse background. Record the number and extent of delamination occurred in the interlayer of each test specimen. Disregard all delamination within 15 mm from an original edge or 25 mm from a cut edge.

7.4 Climate Test (Structural Integrity test for IGU)

Twelve samples of size not less than 502 (±2) mm × 352 (±2) mm shall be selected from the same batch and shall be conditioned for a minimum of 2 weeks in laboratory condition. The climate test for Insulating Glazing Units (IGU) comprises of initial and final dew/frost measurement, climate test part 1, climate test part 2 and initial and final moisture content.

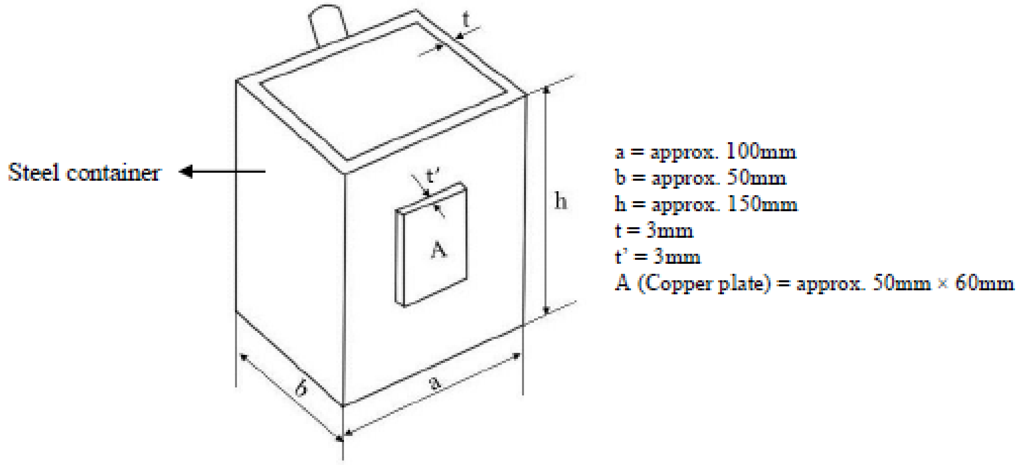


FIG. 41 DEW/FROST APPARATUS

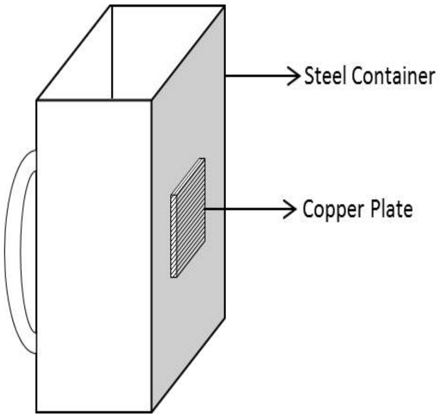


FIG. 42 DEW/FROST APPARATUS

7.4.1 *Dew/Frost Apparatus*

A copper plate 'A' measuring approximately 50 mm × 60 mm × 3 mm shall be brazed onto the center of the larger side surface of a polished steel container (approximately 100 mm × 50 mm × 150 mm), as shown in Fig. 41. Care shall be taken so that the back surface of the copper plate and the front surface of the vessel are brazed completely.

The outward face of the copper plate 'A' shall be polished to be flat and smooth so that surface of the glass specimen adheres closely thereto.

7.4.2 *Dew/Frost Appearance*

The dew/frost appearance inside the IGU shall be checked before and after climate test. The specimen shall be held nearly vertical and the surface to be subjected to contact shall be cleaned with a cloth. Organic solvent (solidifying temperature lower than -35°C such as acetone, ethyl alcohol etc., and having no harmful effect on the adhesives of sealed insulating glazing unit) shall be poured into the vessel to a level above the upper edge of the copper plate and then small pieces of dry ice shall be added with stirring until the liquid reaches prescribed temperature.

The surface A of vessel shall be wetted with organic solvent, and shall be stuck tightly to the specimen surface as shown in the Fig. 43 for the prescribed period of time as given in Table 4 for the respective thickness of the glass pane.

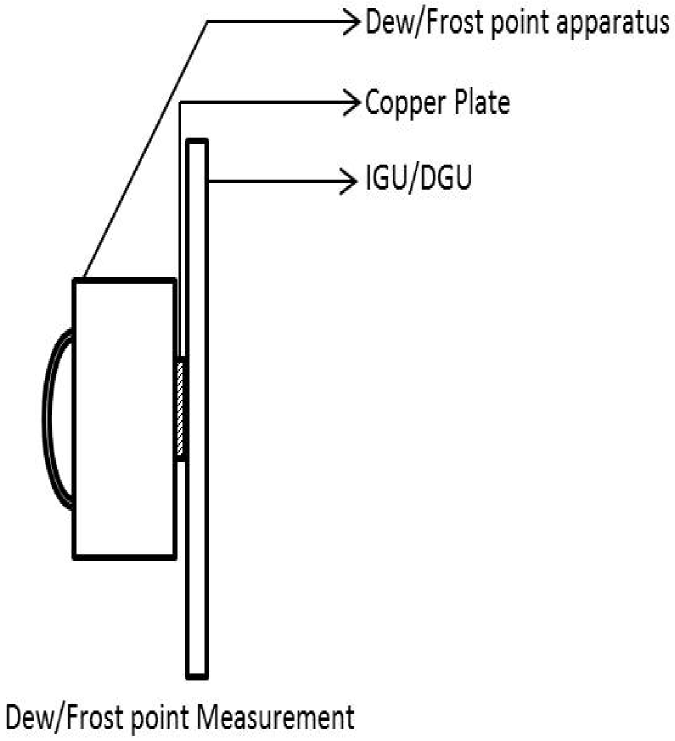


FIG. 43 DEW/FROST POINT MEASUREMENT

Table 4 Sticking Time

Sl No.	Thickness of Glass Pane (mm)	Tight Sticking Time (min)
(1)	(2)	(3)
(i)	3	3
(ii)	5	4
(iii)	6	5
(iv)	8	7
(v)	10 or above	10

During the test, dry ice shall be added to the organic solvent to maintain the liquid temperature within ± 2°C of set temperature. After the test duration, the vessel shall be separated from the specimen and the frost on the contact surface of the specimen shall be cleaned using tissue paper or soft cloth. The sample shall then be observed in front of the observation board, to check for the presence of dewing or frostings on the inside surface of the specimen within 30 s from the time the vessel was taken away from the surface of the specimen.

Perform the test as described above at successively lower temperatures until dew/frost state is observed. Decreasing the temperature during the test at intervals of 10°C is recommended; for example, − 10°C, −20°C, −30°C, − 40°C, −50°C, and − 60°C.

After performing the dew point test on the entire selected test specimen, the samples shall be numbered from 1 to 5 in order of dew point value, commencing with the highest dew point value as number 1 and ending with the lowest dew point as number 5. Dew point less than -60°C should be considered as -60°C and units with dew point value below -60°C shall be numbered randomly. Designate the samples in accordance with the Table 5.

7.4.3 *Initial and Final Moisture Content*

The following procedure shall be followed to measure the initial and final moisture content of the desiccant before and after climatic exposure respectively after performing the test prescribed at **7.4.2**.

7.4.3.1 *Deglazing the test specimen*

The empty weight of the clean/ dry dish (m_o) shall be measured. The glass panes shall be removed by cutting the seal using a sharp knife and the spacer parts shall be separated wherever possible and shall be sawed at the center. Then, the spacer shall be bent by hand and the desiccant shall be poured into the dish. The deglazing should be completed within 5 min and any splinters from spacer should be avoided. The dish should be covered immediately with a lid and then shall be transferred to the weighing apparatus. The dish with the desiccant shall then be weighed without the lid (for m_i and m_f) within 3 min from collecting the desiccant in the dish.

7.4.3.2 *Moisture content measurement*

After placing the lid to ensure that additional dust does not enter the dish and that no desiccant is lost, the dish shall be transferred to the furnace. The lid shall then be removed and the dish shall be heated in the furnace from room temperature to 950°C in 60 ± 20 min. The temperature shall be maintained at 950 ± 50°C for a further 120 ± 5 min. The dish with the desiccant shall then be taken out and covered with the lid and placed in a desiccator for cooling to room temperature. The dish and the desiccant without the lid (m_r) shall be re-weighed. Initial moisture content of test pieces (2, 4) can be calculated using the equation given in **7.4.3.3** and then the test pieces (1, 5) shall be exposed for climate test part I and II.

7.4.3.3 *Initial moisture content (before climatic exposure)*

$$T_i = \frac{m_i - m_r}{m_r - m_o} \text{ or } T_i = 100 \times \frac{m_i - m_r}{m_r - m_o} \text{ in percentage,}$$

where,

T_i = Initial moisture content of desiccant;

m_o = Mass of empty, clean and dry dish ;

m_i = Mass of dish plus desiccant after transfer from IGU; and

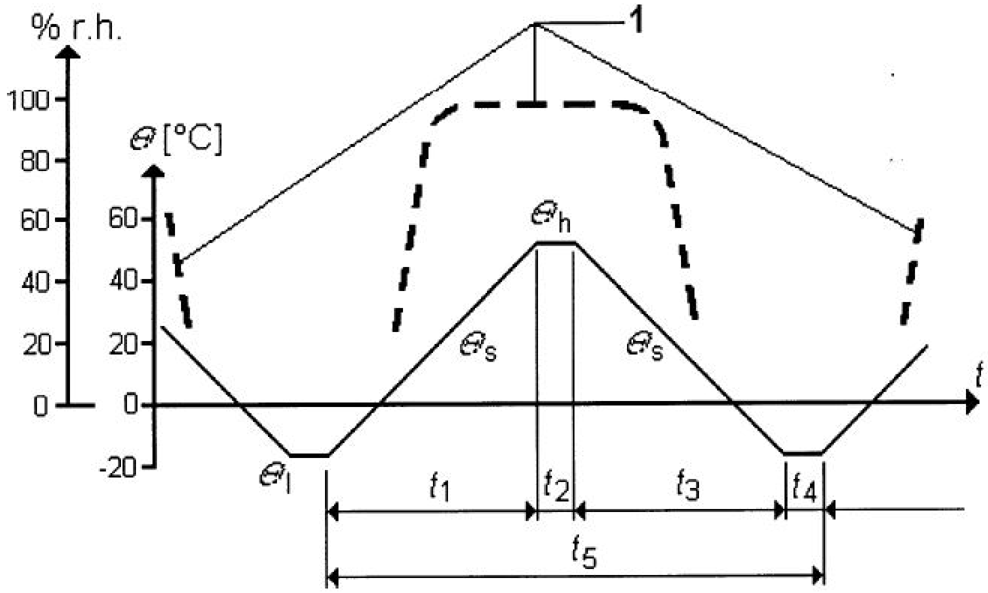
m_r = Mass of dish plus desiccant dried at high temperature.

7.4.3.4 *Climate test part I*

The test specimen 1 and 5 shall be subjected to 56 cycles /four weeks where one cycle consists of 12 h of varying temperature from – 18°C to + 53°C, with slopes of 14 ± 2 °C/h (*see* Fig. 44).

Table 5 Designation of Samples after Dew Point Measurement

Unit Number	Designate Units For
2 and 4	Measurement of initial moisture content (**T_i**) and the gas concentration (**c_i**) when applicable
1 and 5	Climate exposure and measurement of the final moisture content of desiccant (**T_f**)
3	Spare unit to apply for : **a)** when needed, measurement of standard moisture absorption capacity of desiccant (**T_c**) **b)** when applicable of gas concentration (**c_i**)



Key	
1	Relative humidity during temperature cycle. Top value of relative humidity is 95 percent. During the cold part of the cycle, the high humidity is interrupted. Condensation on test specimen from time to time is allowed.
t_1	5 h
t_2	1 h
t_3	5 h
t_4	1 h
t_5	Total duration of cycle (12 h)

FIG. 44 TEMPERATURE/TIME AND HUMIDITY/TIME RELATIONS IN CYCLING STAGE

7.4.3.5 *Climate test part II*

Following the climate test part I, the same test specimen shall be exposed to a constant temperature of 58°C and 95 percent relative humidity for three weeks.

Suitable Environmental chamber/s with facility to heat and cool the environment inside the chamber as per the cycle given in **7.4.3.4** shall be used. If two chambers are utilized for the testing, transferring of samples between the chambers shall not take more than three hours.

In order to maximize uniform climate conditions throughout the cabinet(s) during the testing, the distance between the vertically placed test specimens shall not be less than 15 mm.

After the completion of climate test part I and II, the samples should be conditioned at standard laboratory conditions for 2 weeks. Then the specimen (1, 5) shall be deglazed and the final moisture content of the desiccant shall be determined.

The result of the test shall be expressed as Moisture Penetration Index (MPI) calculated as per **7.4.3.7**.

7.4.3.6 *Final moisture content (after climatic exposure)*

$$T_f = \frac{m_f - m_r}{m_r - m_o} \text{ or } T_f = 100 \times \frac{m_f - m_r}{m_r - m_o} \text{ in percentage,}$$

where,

T_f = Final moisture content of desiccant;

m_o = Mass of empty, clean and dry dish;

m_r = Mass of dish plus desiccant dried at high temperatures; and

m_f = Mass of dish plus desiccant after transfer from IGU (subjected to the climate conditions in the cabinet).

7.4.3.7 *Moisture penetration index*

Calculate the moisture penetration index, in fractions or in percentage, of the designated test specimens subjected to the climate conditions, from the following equation:

$$I = \frac{T_f - T_{i,av}}{T_{c,av} - T_{i,av}} \text{ or } I = \frac{T_f - T_{i,av}}{T_{c,av} - T_{i,av}} \times 100$$

where,

I = Moisture penetration index (can be expressed in decimal or in percentage);

Ti,av = Average initial moisture content of desiccant; and

Tc,av = Average standard moisture adsorption capacity of desiccant.

7.5 Argon Gas Level Test

Ten sealed insulating glazing unit specimens of size not less than 350 mm × 500 mm shall be used, each consisting of at least one lite of clear uncoated glass. The test specimens shall be conditioned at standard laboratory conditions for a minimum of four weeks from date of manufacture to allow for equilibration of the gas before testing.

A gas analysis equipment based on spark emission spectroscopy (high voltage discharge or 'glow discharge') shall be used, which is capable of:

a) analysis of the gaseous constituents essential to the insulation function of the insulating glazing unit, at concentrations of 50×10^{-6}; and
b) determination of concentration of gas in percentage by volume, up to 100 percent with an accuracy of ± 3 percent(relative).

Both the above estimations may not necessarily be performed using the same equipment.

7.6 Light Stability Test

7.6.1 *General*

The purpose of this test is to ensure that laminated safety glass is resistant to the effects of exposure to light encountered during service.

7.6.2 *Apparatus*

7.6.2.1 *A Source of ultra violet radiations*

A radiation source consisting of a medium pressure mercury vapour arc lamp with a tubular quartz bulb (ozone-free type) shall be used. The bulb axis shall be vertical. The nominal dimensions of the lamp shall be 360 mm in length and 9.5 mm in diameter. The arc length shall be 300 ± 14 mm. The lamp shall be operated at 750 ± 50 W. Any other source of radiation which produces the same effect as the lamp specified above may be used. To ensure that the effects of another source are the same, a comparison shall be made by measuring the amount of energy emitted within a wavelength range of 300 nm to 400 nm, all other wavelengths being removed by the use of suitable filters.

7.6.2.2 *Visual light transmission measurement using standard illuminant*

a) *Light source* — CIE standard illuminant A, consisting of an incandescent lamp, the filament of which is contained within a parallelepiped 1.5 mm × 1.5 mm × 3 mm. The voltage at the lamp terminals shall be such that the colour temperature is 2 856 K ± 50 K. This voltage shall be stabilized within ± 0.1 percent. The instrument used to check the voltage shall be of appropriate accuracy.
b) *Optical system* — Consisting of two colourless lenses, L1 and L2, each with a focal length, f of at least 500 mm and corrected for chromatic aberrations. The clear aperture of the lenses shall not exceed $f/20$. The distance between the lens L1 and the light source shall be adjusted in order to obtain a light beam which is substantially parallel. A diaphragm, A1, shall be inserted to limit the diameter of the light beam to 7 ± 1 mm. This diaphragm shall be situated at a distance of 100 ± 50 mm from the lens L1 on the side remote from the light source. A second diaphragm, A2, shall be placed in front of lens L2. The detector of the measuring equipment shall be placed in the focal plane of lens L2. The image of the light source shall be centred on the detector. A diaphragm, A3, with a diameter slightly larger than the cross-section of the largest dimension of the image of the light source is placed in front of the detector in order to prevent scattered light created by the sample from reaching the detector. The point of measurement shall be taken at the centre of the light beam.

Table 6 Generally Accepted Values for the Standard Moisture Adsorption Capacity of Desiccant

Desiccant in Bulk	Tc for Drying at 950°C
Zeolite 3 A	0.20 or 20 percent
Zeolite 4 A	0.20 or 20 percent
Zeolite 10 A	0.20 or 20 percent
Silica-gel micropores	0.25 or 25 percent
Silica-gel macropores	0.12 or 12 percent

Note — Instead of repeatedly measuring the standard moisture adsorption capacity, the generally accepted values from the above table may be used.

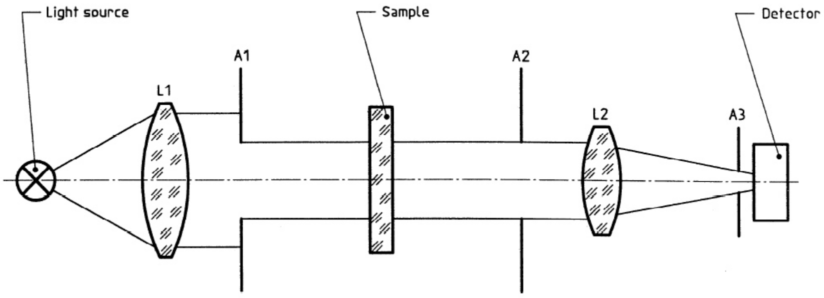


FIG. 45 MEASUREMENT OF LIGHT TRANSMITTANCE

c) *Measuring equipment* — The detector shall have a relative spectral responsivity in substantial agreement with the CIE spectral luminous efficiency function for photopic vision (*see* Table 7). The sensitive surface of the detector shall be covered with a diffusing medium and shall have at least twice the cross-section of the largest dimension of the image of the light source. If an integrating sphere is used as the detector, the image of the light source shall be in the entrance port of the integrating sphere and the aperture of the sphere shall be at least twice the cross-section of the measuring beam at that aperture. The linearity of the detector and the associated indicating instrument shall be less than or equal to ± 2 percent of full scale, or ± 10 percent of the magnitude of the reading, whichever is the smaller.

Table 7 Spectral Luminous Efficiency Function for Photopic Vision

(*Clause* 7.6.2.2 c) and 7.6.2.3)

Wavelength in nm	*Standard Value of* $P_\lambda \overline{Y_\lambda}$ *Under Standard Illuminant 'A'*
380	0.000 0
390	0.000 1
400	0.000 5
410	0.001 9
420	0.008 0
430	0.026 5
440	0.060 9
450	0.116 7
460	0.209 8
470	0.362 4
480	0.619 8
490	1.039 3
500	1.795 6
510	3.084 9
520	4.761 4
530	6.323 0
540	7.598 5
550	8.570 7
560	9.220 1
570	9.457 4
580	9.225 7
590	8.543 0
600	7.546 0

(*Concluded*)

Wavelength in nm	*Standard Value of* $P_\lambda \overline{Y_\lambda}$ *Under Standard Illuminant 'A'*
610	6.359 9
620	5.064 9
630	3.712 2
640	2.558 7
650	1.638 9
660	0.970 6
670	0.532 7
680	0.289 6
690	0.146 7
700	0.074 4
710	0.039 8
720	0.0195
730	0.010 0
740	0.006 2
750	0.002 1
760	0.001 1
770	0.000 0

where,

$P\lambda$ = spectral energy distribution of the incident light at each wavelength; and

$\overline{Y_\lambda}$ = distribution co-efficient defined by CIE.

d) *Measurement of visual transmission*

Adjust the instrument indicating the response of the detector to indicate 100 divisions when the glass sample is not inserted in the light path. When no light is falling on the detector, the instrument shall read zero.

Place the glass sample between the diaphragms A1 and A2 and adjust its orientation in such a way that the angle of incidence of the light beam is equal to 0 ± 5°. Measure the regular transmittance of the glass sample: for every point measured, read the number of divisions, n, shown on the indicating instrument.

The regular transmittance τ_r, is equal to n/l00 and is determined for any point on the glass sample.

7.6.2.3 *Visual tight transmission measurement using spectrophotometer*

Alternate to CIE standard illuminant (A), a spectrophotometer covering the wavelength from 380 to 770 nm may be used to measure visual light transmission. Measure the light transmission of the specimen covering the wavelength from 380 to 770 nm at an interval of 10 nm using a suitable spectrophotometer and express the value of tristimulus (Y) in percent, under the standard illuminant (A) which shall be taken as the visible light transmission.

Value for Y under standard illuminant (A) is to be calculated as follows:

$$Y = \sum P_\lambda T_\lambda \overline{Y_\lambda}$$

where,

$T\lambda$ = spectral transmission of glass at each wavelength;

$P\lambda$ = spectral energy distribution of the incident light at each wavelength; and

$\overline{Y_\lambda}$ = distribution co-efficient defined by CIE.

The standard value of $P\lambda\ \overline{Y_\lambda}$ at each wavelength from 380 to 770 nm at an interval of 10 nm under standard illuminant (A) is given in Table 7. The light transmission is the ratio of Y tristimulus of the light transmitted by the glass and that of the illuminant alone:

$$\text{Light Transmission} = \frac{\sum T_\lambda P_\lambda \overline{Y_\lambda}}{P_\lambda \overline{Y_\lambda}}$$

7.6.3 *Procedure*

Take three specimens measuring 300 mm × 300 mm and determine their visual transmission as described in **7.6.2.2**.d). Next place the specimens at a distance of 23 cm from the source of ultra violet radiation. Expose the specimens to ultra violet radiation for a period of 100 h, maintaining a temperature between 38°C and 49°C throughout the test. After the exposure, again test the irradiated specimen for visual transmission as before.

NOTE — All the three irradiated specimens may be retained for boil test.

7.6.4 *Interpretation of Results*

The specimens shall be considered to have passed the requirements of the test if the following criteria are satisfied:

a) After the irradiation remarkable discolouration (judged against a white background), blister and turbidity detrimental to service shall not appear.

b) After irradiation, reduction ratio of transmission for colourless laminated safety glass should be not more than 10 percent of the original transmission.

NOTE — For laminated safety glass using tinted foil, the transmission after irradiation may be higher or lower than original transmission by 10 percent.

The reduction ratio (l) shall be calculated from the following formula:

$$\text{Reduction ratio } (l)\text{, percent} = \frac{a-b}{a} \times 100$$

where,

a = transmittance (visible) before UV irradiation, and

b = transmittance (visible) after UV irradiation.

ANNEX A

LIST OF SYMBOLS AND ABBREVIATIONS

B	Specimen width
E	Modulus of elasticity (Young’s modulus) of the specimen
F_{max}	Maximum applied force
g	Acceleration due to gravity
h	Specimen thickness
k	Dimensionless factor
L	Specimen length
L_s	Distance between the centre lines of the supporting rollers
L_b	Distance between the centre lines of the bending rollers
M_b	Bending moment
m_i	Mass of dish plus desiccant plus water initially adsorbed
m_f	Mass of dish plus desiccant plus water initially adsorbed plus water adsorbed when subjected to the climate conditions in the cabinet
m_o	Mass of dish when empty, clean and dry
m_r	Mass of dish plus dried desiccant at high temperature
T_f	Final moisture content of desiccant
T_i	Initial moisture content of desiccant
y	Central deflection of the specimen relative to the supporting rollers
Z	Section modulus
σ_b	Bending stress in the surface area defined by the bending rollers
σ_{beff}	Effective bending stress
σ_{bB}	Bending strength
σ_{bG}	Bending stress imposed by the self-weight of the specimen
ρ	Density of the specimen

ANNEX B

(*Foreword*)

COMMITTEE COMPOSITION

Glass, Glassware and Laboratoryware Sectional Committee, CHD 10

Organization	*Representative*
CSIR — Central Glass & Ceramic Research Institute, Kolkata	Dr K. Muraleedharan (***Chairman***)
Asahi India Glass Limited	Shri Praveen Saini Shri Navin Rai (*Alternate*)
Bhabha Atomic Research Centre, Mumbai	Dr (Smt) Madhumita Goswami Dr Purnananda Nandi (*Alternate*)
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Controllerate of Quality Assurance (Materials)	Shri Sunil Kumar Shri H. C. Sharma (*Alternate*)
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The All India Glass Manufacturers Federation	Shri Sourabh Kankar Shri Vinit Kapur/Shri Gopal Ganatra (*Alternate*)
United Breweries Group	Shri S. K. Rastogi
Voluntary Organization in Interest of Consumer Education (VOICE)	Shri B. K. Mukhopadhyay Shri K. C. Chaudhary (*Alternate*)
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(Continued from second cover)

The composition of the technical committee responsible for formulation of this standard is given in Annex B.

In reporting the result of a test or analysis made in accordance with this standard, is to be rounded off, it shall be done in accordance with IS 2 : 1960 ‘Rules for rounding off numerical values (*revised*)’.

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This Indian Standard has been developed from Doc No.: CHD 10 (11078).

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

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Published by BIS, New Delhi